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(54) Title: VIDEO MEDIA SECURITY AND TRACKING SYSTEM

(57) Abstract

A system for providing security and tracking data for rental video media, including digital video discs and digital video cassettes. Those new formats for video players and media allow for inclusion of security features which both allow tracking of rental of such media and prevent unauthorized rental thereof. Each player includes a decision circuit which plays a particular disc (or tape) only if a player identification number recorded on a special separate authorization memory card is the same as the player identification stored in the player, and if a movie identification number optically read from the disc matches a movie identification number recorded on the special card. A corresponding apparatus is provided at the video rental store which, at the time of rental, records on the authorization card in encrypted form the movie identification number and the number of the particular disc player for which that rental is intended. The encryption uses the private key of a public key system, the public key and the modulus being pre-recorded on the optical portion of the disc.

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VIDEO MEDIA SECURITY AND TRACKING SYSTEM

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BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to security systems for video media and more particularly to a system for allowing an owner of copyrighted video material to control, on a per use basis, viewing of that material provided on a prerecorded medium such as a video disc or video tape cassette.

Description of the Prior Art

As is well known, typically video tape cassettes or video discs containing prerecorded material such as movies are commercialized as follows. The owner of the copyrighted material on the video cassette or disc, i.e. the movie studio ("rights owner"), arranges for duplication of the movie onto a large number of video tape cassettes or discs. The video tape cassettes and discs are then sold by the movie studio to owners of video rental stores who then rent each video tape cassette or disc out as many times as they can, depending on demand. However, the owner of the video rental store only pays for each video tape cassette or disc once, because he has purchased it outright from the movie studio. Thus the bulk of the profits due to rental of such material accrue to the video rental store owner rather than to the movie studio. This is because the so-called "first sale doctrine" prevents the seller (the movie studio) of the video tape cassettes or discs from exercising any degree of control over the downstream commercialization (e.g.,

rental) of its products. This is the case even though the video material is copyrighted.

It has been frustrating to the rights owners (movie studios, etc.) that they are not able to better control and/or profit from the rental market for their movies and other program material. Various methods have been proposed to allow the rights owners to overcome the first sale doctrine and acquire some degree of control over the rental of, for instance, VHS video tape cassettes.

One proposed method uses a "non-rewindable" cassette. Once played by the consumer (renter), the cassette must be returned to the rental store for rewinding. The rewinding machine is such that it automatically records each rewinding transaction and the movie studio (or its agent) can then periodically check the rewinding machine, either on the spot or by telecommunications, for a transaction-by-transaction record. This of course requires some business arrangement between the video store owner and the movie studio to pay for the video cassette on a per use basis. Such arrangements are contractual matters outside of the purview of this patent disclosure.

The non-rewindable cassette has the obvious disadvantage that each renter may watch each movie only once per rental. This is frustrating to the renter who may wish to watch the movie more than once. There is also obviously a temptation on the part of the video store owner to tamper with the rewinding machine and hence end up paying fewer for rentals of the cassette than he is obligated to pay for.

A second proposal now being tested involves installing a special integrated circuit in each individual video tape cassette. This circuit turns itself on a predetermined time after being armed and radiates an interfering radio signal to the VCR

electronics, thus effectively prohibiting further playing of that video tape cassette until it is returned to the rental store for reprogramming of the circuit. Again, the reprogramming machine automatically records the reprogramming transaction. So far this proposal has limited support due to the cost of the circuit in the video tape cassette, possible consumer inconvenience if the circuit malfunctions, and the ease with which it could be cheated by the video store operator or so-called "hackers". (The term "hacker" herein refers to anyone attempting to defeat system security by technical means.) The same deficiencies apply to the non-rewindable cassette approach. The circuit inside the video cassette also requires provision of a battery to power such a circuit, with the attendant practical complications.

Other proposals involve mechanical or electronic counters installed in each video tape cassette to count the number of plays. Again, this is problematic if a particular renter might want to play the video tape cassette more than once, and also is easily overcome by tampering.

It is to be understood that the video store owners interests in this regard are to a large extent the same as those of the rights owners. If a reliable system could be found to share rental revenues between the rights owners and the video store owners, then the rights owners would provide many more copies of each movie for rental to each store, hence increasing profits for both parties.

None of the above security systems are feasible for use with, for instance, video discs, which are soon expected to become very popular in new digital formats. Additionally, it is to be understood that the deficiencies of the above systems are a consequence of

constraints imposed by the requirement that any such security system must be compatible with the large installed base of VCRs. Thus the proposed solutions to this problem are essentially unsatisfactory and none have been widely implemented.

SUMMARY

The present inventors have recognized that it is advantageous if a security system, instead of being forced to operate with the constraints of the present installed base of VCRs, instead uses a player compatible with new recording media specification(s) and includes a dedicated low cost rental control subsystem. Such a security system is especially suitable in anticipation of the introduction of new formats for video media such as the Digital Video Disc (DVD) and the Digital Video Cassette (DVC).

Implementation of the present security system requires that a significant proportion of the rights owners agree on the desirability of being able to better control commercial use of their copyrighted materials for the new formats, and as a consequence that the manufacturers of the players would be receptive to making compatible players in the expectation of increased support for their formats.

In accordance with the present invention, the present inventors have identified several important security system attributes. One is functionality, that the system track and report each rental transaction both by program (movie) title and length of time (days or hours) rented out. Further, the system should be capable of segregating transactions by, for instance, movie studio, and downloading this information on a periodic basis by e.g. the telephone lines to a transaction service center or to particular copyright owners.

The next attribute is a high level of system security; the present system is believed to be impossible (or prohibitively expensive on a practical basis) for unscrupulous video rental store owners (or hackers in collusion with video rental store owners) to cheat on or to compromise. Thus in accordance with the invention the rights owners can be confident that they are properly recompensed for rental activity. In the event of any security breach, in accordance with the invention it is possible quickly and inexpensively to recover from the breach and minimize resulting losses. Also, in accordance with the invention, there is tracking system security, in that particular rights owners are assured that transaction data relating to their particular video material (movie titles) is not accessible by others.

Another attribute is that the present system is operationally simple, providing minimum operational burden to the employees of the video rental store. Similarly, the users (renters) enjoy operational simplicity so that the system is essentially transparent to the renter of the video material and does not interfere with his enjoyment of the rented material.

As a last attribute, the present system adds minimal cost both to the players and the media. In addition, the cost of the in-store transaction monitoring and reporting equipment is believed to be quickly recoverable.

One embodiment in accordance with the present invention is directed to the digital video disc format medium. However, it is to be appreciated that the present invention is also applicable to systems using analog or digital video cassette tapes or analog video discs or other media using magnetic, optical or magneto-optical or other types of recording. This

system is also applicable to other than video material such as audio material. (However, generally audio media are sold outright and not rented.)

Moreover, while one embodiment disclosed herein involves digital video disc media, it is to be understood that the invention is not particular to digital material but is also applicable to analog recordings.

In accordance with the invention there is a "TTRD" (transaction tracking and reporting device) which is an apparatus for use in a video store, and a method of using the TTRD to record, on a separate authorization card, in encrypted form of a program (movie) identification for the material prerecorded on the disc or tape and also in encrypted form the identification of a particular player. The authorization card is a reusable memory card having a capacity of about 100 bytes and being semiconductor, magnetic, or other suitable memory technology.

In addition, in accordance with the invention there is provided a modified player (a DVD player or video cassette tape player) which in addition to the conventional circuitry includes dedicated rental control circuitry and/or software for reading, from the prerecorded material on the medium, rent/sell authorization data, a public decryption key, and the program identification. Also provided in the player is a slot to accept the authorization card for reading the authorization card and connecting via a data decoder and error correction circuitry to a decryptor. The decryptor also receives the public decryption key which was optically recorded on the disc, and thereby decrypts from the data on the authorization card the program identification and the player identification. A special decision circuit in each player compares the player identification from the authorization card to

that stored in a read only memory in the player, and also compares the program ID from the decryptor to the program ID provided from the prerecorded material. Only if both the two player identifications are authenticated (match) and the two program identifications are authenticated (match), is the player enabled to play the prerecorded material.

Of course if authorization data indicating that this is a sell-through (non-rental) disc is present on the disc, i.e. there is a authorization indication to play, then even if no program or player identification matches are made, the player is enabled to play the prerecorded program material.

Also therefore in accordance with the invention is a method of operating the player to authorize its operation to play the prerecorded material.

In an alternative embodiment, the authorization card is not used and instead a writable (e.g. magnetic) memory is located on the disc itself, by providing a narrow circular magnetic track near the center of the disc, to be read by a special magnetic head in each DVD player.

The last element is the prerecorded media. In the case of the DVD disc, this is a video disc including (in the alternative embodiment) the magnetic track located at a convenient location, such as near the disc center. The magnetic track on the disc as it comes from the factory and is shipped to the video rental store is typically blank but has space sufficient to record on it the encrypted program identification and encrypted player identification.

It is to be understood that hereinafter when reference is made to the authorization card, in the alternative embodiment this refers to the magnetic track on the disc or an equivalent for a video tape cassette.

In the case of a video tape cassette suitable for use in accordance with the present invention, recorded on the video tape at a convenient location(s) is the data decryption key and the program identification. Recorded at another location only in the alternative embodiment (for convenience of reading by the TTRD without rewinding of the video tape itself) is a second separate magnetic track which is sufficient size to include space for recordation of the encrypted program identification and encrypted player identification. The location of the second magnetic track may be for instance on the outside of the cassette housing. Thus when the video tape cassette is inserted into the TTRD (or the VCR), the insertion and corresponding movement of the cassette into the TTRD (or VCR) passes this track past a fixed magnetic head and hence allows easy reading thereof. In another version of the alternative embodiment, the second magnetic track is located on the end of one of the video tape cassette spindles, and hence the spinning of these spindles moves the magnetic track past a suitably located small magnetic head. In either case, there is no need to search for the encrypted data on the video tape itself.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a transaction tracking and recording device in accordance with the present invention.

Figure 2 shows a player in accordance with the present invention.

Figure 3 shows a video disc in accordance with an alternative embodiment of the present invention.

Figure 4 shows a video cassette tape in accordance with the alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In a Digital Video Disc (DVD) embodiment, each DVD player, which is otherwise of a conventional type recently announced, for instance, by Toshiba or Sony or any other type, includes embedded in an internal memory a stored identification. This identification (e.g., a number) need not necessarily be the same as the player serial number. This identification is e.g., at least 6 or 8 decimal digits for best security. The player identification may have significantly fewer digits than the player serial number, for instance, having as little as two decimal digits at a penalty of reduced security. Thus the player identification need not be unique to each digital video player, but is a number large enough so it is not likely to be easily duplicated amongst the number of individual DVD players which a hacker may encounter.

Each corresponding digital video disc intended for the rental market includes, in addition to the normal optical prerecorded track in the alternative embodiment only, an additional narrow circular magnetic recording track located for instance near the center of the disc (this location is illustrative and not limiting). This track need hold approximately only 100 bytes of data. The magnetic track is read by a magnetic read head provided in each DVD player in accordance with the present invention. It is to be understood that the industry proposed DVD players do not include the slot to accept the authorization card (or in the alternative embodiment the magnetic head) and associated circuitry, and the addition of these elements is a required modification to DVD players in order to practice the present invention.

Each DVD disc intended for rental also will contain a number of extra bytes of information optically recorded during the conventional mastering of

the disc, as part of the disc initializing information. In conventional CDs for instance, and also in the proposed DVD discs, there is a scan region which is read by the player in the initialization cycle of the disc. The initialization information conventionally includes data such as running time, number of tracks, and perhaps location of particular portions of the recorded material. In accordance with the invention, each rental disc will include, in addition to the conventionally provided information in the initialization region, a number corresponding to, for instance, the particular title of the movie recorded in the optical portion of the disc (a movie or program identification) and additionally an instruction telling the player to read the magnetic track of that particular disc to obtain authorization to play the disc. Discs intended for the sell-through market, i.e. to be sold at retail to consumers, will not include such an instruction to seek authorization. To put this another way, discs intended for the sell-through market will include an instruction which does not require the player to read the authorization card for authorization to play the disc, but will authorize the player to play the disc without consulting the authorization card.

The information recorded on the authorization card includes the movie identification(s) and the player identification of a particular player or players authorized to play that disc. This information on the authorization card is encrypted and recorded at the time of the rental transaction by the transaction tracking and reporting device (TTRD), provided to each rental store in accordance with the present invention. "TTRD" is nomenclature used herein for convenience to refer to a device as described in detail below. It is to be understood that such a device need not necessarily be a stand-alone device but may for

instance be incorporated into other transaction reporting equipment already present in video rental stores, with appropriate features as described below.

A conventional electronic clock in each TTRD records, for each rental transaction, the time and date of authorization and later records when the particular disc was returned to the rental store after the rental was completed.

Each DVD player, which is otherwise conventional, also includes a decision circuit which allows that particular player to play a particular disc only if its player identification matches the authorized player identification read from the authorization card, and also if the movie identification optically read from the disc matches the movie identification read from the authorization card).

When a rental customer first becomes a customer at a particular rental outlet or rental chain, the customer provides the rental store employee with the player identification of the customer's own DVD player. This identification, along with e.g. the customer's name and/or telephone number, is entered into the TTRD via e.g. a standard keyboard interface or by a bar code reader. Thus for instance a particular customer can become a member, as now, at any number of rental stores and thereafter need only provide conventional information, i.e. name or telephone number or rental identification card, to rent a disc.

When a particular disc is rented, it is inserted by the rental store employee into the TTRD which then optically reads from the disc the movie identification from the disc's initialization region and records it, along with the customer's player identification, on the authorization card. This operation is automatic and takes only a few seconds.

The authorization card is supplied by the rental store at the time of each rental; one card may include information for several rented discs. The cards will cost about $1 each to manufacture, and are reusable. The authorization card approach is less convenient to the rental store and renter than is the magnetic track on the disc, since an extra physical item is involved. The card may be sized to fit inside the disc "jewel case" to minimize risk of loss. However, the authorization card approach is less expensive in terms of cost of manufacturing the players. The security and functionality of the system are independent of the authorization media employed.

After the customer has finished using the disc and returns it to the rental store, the rental store employee briefly inserts the disc in the TTRD which reads both the magnetic and optical data and records in the TTRD memory the data and time of the return. The TTRD then has a complete record of the transaction.

This system provides the above described advantages. In terms of functionality, for transaction tracking information the electronic clock in the TTRD notes each disc's time and date of authorization and when it was returned to the rental store. Combined with the movie title and renter's player identification if desired, this is sufficient information to track rental activity. It is to be noted however that in certain embodiments of the invention the rental tracking features are not necessary and only the below-described security features are included. Thus in certain applications where the rights owner may for instance not require transaction information but merely wants security, the functionality of transaction tracking and the accompanying structures may be dispensed with.

One added advantage of the present system is that it prohibits a particular renter from lending his rented disc (or tape) to a friend or relative, since only the particular renter's DVD player has been authorized to play any particular disc. This feature may advantageously generate extra rental transactions. If a particular customer owns more than one DVD player, the system accommodates this by allowing the recordation of more than one player identification on the authorization card (or on the disc magnetic track). The system prohibiting lending to a friend may then be circumvented by a customer listing his friend's player as his own. (This would of course be found out if the friend then were to rent a disc on his own from the same rental store or rental store chain.)

A major advantage in accordance with the invention is that system security is maintained even though a hacker acquires complete knowledge of the security principles used and is also fully capable of probing the entire operational details of the authorization circuits in a particular DVD player. That is to say, the DVD player itself holds no secrets and yet the system is still secure. The security system has two aspects. The first is preventing illicit transactions. The second is restricting access to the transaction data in accordance with the transaction reporting system. Of these, the first is probably more important.

In order to prevent illicit transactions, that is to prevent a hacker from designing a "black box" device to illicitly record authorization data on an authorization card, this data (the player and movie identification) is concatenated and encrypted and written on the authorization card (or on each disc) by the TTRD, using a public key encryption system. Such

systems are well known. The following is a brief review of pertinent encryption methods.

The most common form of data encryption and best known to the layman, is called private key or symmetrical encryption and is the method historically used for encryption. Such methods use the same key to encrypt and to decrypt data. To guard against trial and error attempts at guessing the encryption key, the key is usually a large number, i.e. an 18 decimal digit number. The DES (data encryption system) algorithm is an example of a private key system in which data, arranged in 64 bit blocks, are encrypted using a 56 bit key. (Fifty-six bits are equivalent to approximately 17 decimal digits.)

In private key encryption systems, as is well known, the chosen key must be kept secret from hackers (or any one with an adverse interest) to ensure security. However at the same time the key must be provided to a potentially large group of legitimate users. In a typical (military) context, there is a relatively small number of legitimate users and hence such systems have historically been used somewhat successfully. However, for the present purpose each DVD player must include the decryption key in order to read the authorization medium. Thus hackers, who can easily buy a DVD player, would have at least in some form access to the key, hence substantially reducing system security. That is to say, it is unrealistic to believe that the decryption key used in such a player would be protected against the determined effort by a hacker to read it, given the low cost and ubiquity of the players. Therefore it is believed that a private key encryption system is more likely to be penetrated, but however may be used in accordance with the present invention where the above-described drawbacks may be of less importance.

The other type of data encryption uses a public key and is also referred to as asymmetrical encryption. Thus there are two different keys in such a system. The first is the private key, known only to authorized users as in the above described private key system; the second key is the public key which may be widely known without risk of system penetration, i.e. hacking. One key (either key) is used for data encryption and the other key is used for decryption. An essential feature of all public key systems is that knowledge of the decryption key does not allow the hacker to encrypt a message and vice-versa.

The most secure public key system commercially available is from a company called RSA Data of Redwood City, CA. The security of this system is predicated on the difficulty of factoring very large numbers, containing upwards of one hundred decimal digits. The fastest known factoring algorithm running on the fastest computers typically takes decades to factor such numbers. The larger the key, the more difficult factoring becomes. In practice, the size of the key is chosen to reduce the cost effectiveness of a factoring effort to unacceptable levels for a would-be hacker, throughout the expected life of the product and with due allowances for anticipated increases in computing power.

In accordance with one embodiment of the present invention, the private key of the public key system is used for encryption. Thus this key is securely stored in each TTRD in such a manner that any attempt to extract the private key from the TTRD causes erasure of the key. This is relatively easy to accomplish since there are limited number of TTRD devices (typically one per rental store) each of which is electronically polled from time to time for ordinary transaction purposes. Hence any breach of security is likely to be

easily detected. The technical means for protecting such keys embedded in an integrated circuit in the TTRD are well known. One simple method is that an attempt to open the TTRD housing results in immediately erasure of the private key. Similarly, since the key is likely to be embedded in a volatile memory, any attempt to electrically contact the leads of the memory results in erasure of its contents. Other types of security interlocks are well known, and multiple interlocks may be provided. Additionally of course, any successful attempt to obtain a data from a particular TTRD would point to the custodian of that TTRD as a likely conspirator. The mere existence of such knowledge would, it is believed, reduce penetration attempts.

The corresponding public key needed for decryption of the DVD player is optically recorded on the disc along with the aforementioned movie identification and the authorization (rent/sell) instruction, as part of the ordinary optically recorded content of the disc. When the disc is to be played, this key is read by the DVD player and is used to decrypt the data on the authorization card, in order to enable playing.

The public key is recorded optically on each disc rather than stored in each DVD player in order to permit quicker recovery from a security breach. In the unlikely event that the current private key became known, thereby threatening system security, a new pair of keys could quickly be generated. The new private key would be downloaded (i.e. via telecommunications) to each TTRD and the corresponding new public key would then be used on all new discs to be manufactured from that day on. Thus revenue losses would be restricted to video rental stores which obtained an illicit authorization device from a hacker, which now could be used only to authorize playing of movies released before the date of the key change. Furthermore, any

abnormal reduction in rental transaction reporting of particular movies released before the security breach occurred, from a particular rental store, would indicate that store was a possible illicit operator.

In order to allow TTRDs to continue to authorize older movies after a new pair of keys is distributed, each TTRD would store the full history of keys used, organized by serial number, and automatically encrypt the data to be recorded on the authorization card with the appropriate private key. This is accomplished by appending the key serial number to the public key recorded on the disc's optical track. The TTRD reads the serial number first and then selects the appropriate private key to perform the encryption from the set of private keys stored in the TTRD in its memory.

The movie ID is both recorded optically on the disc and encrypted (along with the authorized player ID) on the authorization card for two reasons. The first reason is to permit TTRDs to track which particular movies are being rented. The second reason applies to system security; if data recorded on the authorization card were merely an encrypted instruction that would authorize any disc to be played by a DVD player having a particular identification, then that encrypted data stream could be obtained by a hacker and reused later. This would be done using a hacker's device to record the data stream on the authorization card. This would illicitly authorize playing of other movies by the same DVD player (that is, for the same customer).

A vital feature of a public key encryption system is that it is not possible to deduce what the encrypted data would be for a block of data which differs by as little as one bit from a block of data whose encrypted value is already known. In other words, knowing the

encrypted data for an instruction to allow e.g. movie number 566 to play on a player with player ID 1289, would not allow a hacker to deduce what encrypted data would correspond to an instruction to allow movie number 567 to play on the identical player. Thus the most a hacker could do would be to note the code sequence which authorizes playing a particular movie for a particular player and later reuse that same code sequence with the same customer desiring to rent the same movie at a later time. Thus at most such hacking would obtain for the unscrupulous rental store owner one additional rental without having to pay the rights owner for that one particular rental. The effort required to do this seems to vastly outweigh any likely financial gain and hence it would not be done.

In terms of restricting access to transaction data, the system also uses in one embodiment a public key encryption system (not the same one as above in terms of the keys themselves) to report transactions. Thus each rights owner (e.g. movie studio) is assigned a unique private key/public key pair. Each TTRD stores the public key of each studio. Transaction data relating to a particular studio is encrypted within the TTRD prior to storage and transmission of same, using that studio's public key. Only the studio (or its agent) is provided with the corresponding private key needed to decrypt the transaction data.

The rest of the system provides operational simplicity because at the time of rental, the video rental store employee must enter the renter's name or telephone number as is done conventionally using either a keyboard interface or a bar code scanner from an identification card including identification number, and then the employee additionally in accordance with the invention inserts the renter's authorization card and the particular rented disc in the TTRD. In the

first embodiment using the authorization card, the TTRD includes a plug in socket for electrically connecting to the authorization card. In the second embodiment using a magnetic track on the disc, the TTRD includes a special recording head to record on the special magnetic track on the disc (or tape cassette).

The TTRD in either embodiment includes a port and loading mechanism such as those of a DVD player. The authorization card and the disc are ejected in a few seconds and the first part of the transaction is automatically recorded. When later on the renter returns the disc (or soon thereafter) the employee again inserts the disc in the TTRD and indicates the return transaction on its keyboard interface. The final part of the transaction, i.e. the time of disc return, is now recorded and the disc is again ejected and replaced on the store shelves. The authorization card is merely returned for later reuse. Transaction reporting to the rights owner or its agent is done automatically, for instance via modem and telephone lines, at a convenient time. Transaction reporting may also be done by other well known means. Thus the effort required of the video rental store employee is only slightly greater than that required in existing rental stores using point of sale terminals to store customer information and bar code readers to check out and check in video tape cassettes or discs.

Additionally, customer convenience is provided in accordance with the invention. Additional effort required by the customer is that when he first signs on (becomes a member) at a particular rental store or rental store chain, the customer provides the store employee with his player identification (or identifications if he owns several players). Each DVD player thus for convenience would be sold along with several cards printed with the player identification in

type and e.g. bar code or a magnetic stripe. The player identification is also stamped on the rear panel of each DVD player along with the serial number. Thus the extra effort in providing one's player identification is a one-time effort accomplished when one first becomes a video rental store member.

It is believed that the cost of implementing the present system is low. The cost of including in the alternative embodiment a magnetic read head and the associated authorization circuitry in each player is estimated to be $1; the most of this cost is the magnetic read head and its associated amplifier. Thus the cost is significantly less for the authorization card embodiment. The remainder of the needed circuitry is typically in the integrated circuitry already included in the player at only very slight additional cost. It is to be noted that much of the circuitry may, of being actual logic circuitry, instead be software in the microprocessor which operates the DVD player.

It is estimated that for the alternative embodiment the cost of providing the circular magnetic track on mass produced discs is $.01 to $.05 per disc. This magnetic track would be narrow and need not be of high density, since the actual amount of data recorded on the track is small.

While the cost of each TTRD would be substantial, only one such device need be provided per video rental store and these devices could be mass produced due to the large number of video rental stores.

Figure 1 shows in a block diagram one embodiment of the TTRD which is located in the video rental store. This device includes a conventional video disc optical reader 12 of the type conventionally found in disc players and in this case typically of the type used in a DVD player. It is to be understood that the

references herein to DVD players are because it is anticipated that the present invention is most likely to be adapted in such a new video media standard. However, the present invention is compatible with other video disc and tape formats. (Of course, present video disc and tape players do not include the circuitry needed to implement the present invention.) It is to be understood that the disc optical reader 12 includes conventional mechanical elements (not shown for simplicity) for spinning the disc 14.

In the conventional operation of a DVD player, after insertion of the disc into the player, the player scans a region of the disc located near the center called the initialization region in order to obtain information about the contents of the disc recorded there which is typically presented on a display of the disc player. In accordance with the invention, this initialization region has recorded on it, in addition to the conventional information, the program (movie) identification, the rent/sale indication and the decryption key which includes conventionally the key serial number, the public key, and the key modulus. Typically, the program identification need not be in alphanumeric form but may be merely a code number i.e., a 6 or 8 decimal digit code. It might be as few as 4 decimal digits to uniquely identify for instance each movie released during a period of several years.

The disc optical reader 12 reads from the optically recorded portion of the disc 14 via conventional laser reading mechanism 18 two pieces of data; these are (1) the key serial number, the public decryption key, and modulus and (2) a program identification number. This data is located as described above in the initialization region of the disc which already contains formatting information pertaining to the disc contents.

The disc optical reader 12 extracts this data from the stream of data read from the disc by laser reading mechanism 18. The key serial number is then (in one embodiment) provided to a key memory 22 which stores, in a secure fashion as described above, a list of private encryption keys for a public encryption key system. Thus the key number is in effect an address which indicates which particular key stored in key memory 22 is the one to be used as the private encryption key. This private encryption key is then provided to an encryptor 26 of a type commercially available from e.g. RSA Data as described above. Typically, this encryptor is actually a set of software routines (a computer program) to be executed conventionally by a microprocessor. The data encrypted by encryptor 26 is the program identification provided from disc optical reader 12 concatenated (in a block of data) with a particular player identification. This player identification is provided as described above from a memory 30 which is part of the TTRD, or entered for instance by keyboard or bar code reader at the time of the transaction. The player identification is that of the particular player belonging to the rental customer.

The program identification in addition to being used for tracking also increases system security. That is, if there were no program identification, the only information recorded on the magnetic track of the disc would be the encrypted player number. Thus a hacker could breach the security of the system by reading the authorization card to obtain the code to authorize play, i.e. enable use of a particular player, by merely reading and recording the encrypted data pertaining to that player number. There is no need in this case for the hacker to decrypt this number but he merely needs to record the appropriate encrypted data on the

magnetic track of the disc without using the TTRD, i.e. bypassing the TTRD, and thus cheating the rights owner by not recording the particular rental transaction. Thus by providing a piece of information which is unique to each rental transaction (a program identification number) and given the use of a public key system, it is made impossible for a hacker to determine what the encoded data would be for a different movie for the same player, due to the nature of public key encryption systems.

Thus it is to be understood that information other than the program identification could be used for this purpose. That is, when each particular optical disc is produced, instead of providing on the optical track a program (movie) code number, instead a random number is provided. Then the TTRD would read this random number, encrypt it and record the encrypted random number on the authorization medium. Thus the term "program identification" used herein does not refer necessarily to a number used universally for all discs carrying a particular movie, but instead to any number or information pertaining to a particular disc or video tape. Thus the program identification need not be unique to each movie; possibly a limited field with few as e.g., numbers 0 to 100 would be adequate to provide security, even though thus several movies might have identical program identifications. Thus for purposes of security alone, the program identification need not be a movie (title) identification. However, to maximize security, each movie should have a unique identification number.

Encryptor 26 then encrypts this data and provides it to a data coder 34 which formats and codes the data into a particular conventional modulation scheme as desired. Authorization card 35 is connected to data

coder 34 by slot connector 33, to record the coded data on card 35.

In the alternative embodiment, also shown for simplicity in Figure 1, the coded data is then provided to a conventional amplifier 38 which drives a magnetic recording head 42 of the type commercially available. Head 42 then records the data on the magnetic track provided on disc 14. As described above, typically this magnetic track is near the hub of the disc but this location is not limiting. It is to be understood that typically both embodiments would not be used in any one TTRD.

This being a rental type disc, prerecorded on the optical track is an instruction (perhaps only a single bit in a predetermined location) indicating that this is indeed a rental disc. In the absence of such instruction, this disc is understood by the player (as described below) to be a disc that has been sold to the user. If a "sell" disc is accidentally subject to the TTRD process as described above, this will have no effect on the use of the disc for reasons described below.

After the encrypted program identification and player identification are recorded on the card 35, card 35 and disc 14 are ejected from the TTRD and both given to the rental customer for his use.

Also a part of the TTRD of Figure 1, but not needed for security reasons, is the tracking and reporting portion 52 including a data coder and formatter 46 which receive the program identification from the disc optical reader 12. Also provided via an electronic clock (not shown) is a date and time indication of the time of the rental transaction. These two items of data are conventionally coded and formatted into suitable form and provided to for instance a modem 50 which then transmits this

transaction data to a central tracking computer, for instance for each movie studio, via telephone lines. It is to be understood that the tracking and recording portion 52 is not needed for security reasons but is provided for commercial reasons to allow each movie studio to determine the number of rentals of its films.

In this system the particular player number is purposely not provided to the data coder and formatter 46. Such could be done but it is not believed necessary for commercial tracking purposes. By not providing such information, a greater degree of privacy is provided to the rental customer.

It is to be understood that with minor modifications, the TTRD of Figure 1 is suitable for use with a video cassette tape. In this case, the laser system 18 is replaced with a VCR (magnetic) read head. Further details of the video cassette embodiment are provided below.

While Figure 1 is a block diagram, each of the blocks represents a conventional commercially available element and moreover, the interconnections between the blocks are well within the skill of one of ordinary skill in the art.

The rental customer then takes the rental disc 14 and card 35 to his home and inserts both in his player which is shown in block form in Figure 2.

The player of Figure 2 includes several major elements common to all video disc players. These include a drive (not shown for simplicity) for the disc 14, an optical read device which in this diagram is a laser system 60 (similar to element 18 of Figure 1), and a disc optical reader 62 similar to optical reader 12 which drives conventional player electronics 66. Thus elements 62 and 66 are conventional and of the type that would be provided in any video disc player, even one not in accordance with the present invention.

The data stream from laser system 60 is provided to the disc optical reader 62 which then provides demodulated and decoded data to the conventional player electronics 66, which is typically connected to a television set or monitor for viewing.

The other elements shown in Figure 2 are added in accordance with the present invention to achieve the desired security. In the authorization card embodiment, these include a slot connector 73 which connects to authorization card 35.

In the alternative embodiment, also shown in Figure 2 for simplicity, these additional elements include a magnetic read head 70 having a structure similar to that of write head 42 in Figure 1 and being adapted for reading the magnetic track on disc 14. The signals from magnetic read head 70 are provided to a conventional analog amplifier 74. The performance of the magnetic read head 70 in the player need not be high; since the total amount of information recorded is approximately 100 bytes, the signal frequency is on the order of 10 KHz and hence a low cost and simple magnetic read head and amplifier would be adequate. It is to be understood that typically both embodiments would not be present in any one player.

The signals from amplifier 74 (or connector 73) are provided to a conventional data decoder 76 which is the complement of data coder 34 in Figure 1. The information recorded on the magnetic track on the disc in the alternative embodiment typically would be recorded using some form of modulation for the purpose of matching the recorded signal to the capabilities of the media. This modulation is typically called channel coding. Various methods of channel coding are well known. Thus in the player the magnetic reading circuitry includes data decoder 76 to decode (demodulate) this data in the alternative embodiment.

A typical method of coding suitable in accordance with the present invention would be frequency shift keying. Another suitable method is quadrature phased shift keying. Decoder 76 thus provides a conventional digital signal from the analog read signal from the head and amplifier. In the authorization card embodiment, decoder 76 would be a simpler digital circuit or may even be dispensed with.

The decoded data (in digital form) is provided to conventional error correction circuitry 78 to find and correct any errors in the data. The corrected data is then provided to a decryptor 80 which is the complementary device to encryptor 26 of Figure 1. It is to be understood, however, that in the public key/private key system described above, the encryptor and decryptor are not simple complements of each other, in order to provide heightened security. The structure of decryptor 80 is that of the type commercially available from, for instance, RSA Data for their public key system.

The demodulated and decoded data (but not encrypted) from the disc optical reader 62 is provided to a rental control circuit 84. The function of circuit 84 is to pick out the relevant data. This is relatively simple since the relevant data are known to be in particular locations of the initialization region of disc 14. The rental control circuit 84 selects three data items from the stream of demodulated and decoded data. The first item data is the program identification ("program ID"). The second is the decryption key (including the modulus). The third is the indication of authorization which provides an indication of the disc being a rental or sell disc. In this embodiment, the authorization indication is a single bit; if the value of the bit is 0, this is a rental disc. If the value is 1, this is a disc for

sale. The authorization bit need not be encrypted. The key (including the modulus) (this is preferably the public key) is provided to decryptor 80 for purposes of decryption. The program identification is provided to a first comparator 90 as a first input thereof. The second input to comparator 90 is the decrypted program identification provided by decryptor 80 from the data read from the authorization medium.

A second comparator 94 has as a first input the player identification from a read only memory (ROM) 98 included in the player, providing a player identification number which may be for instance a number as small as two decimal digits but preferably would be somewhat higher. The second input to comparator 94 is the decrypted player identification from decryptor 80 from data on the authorization medium. The comparison function for comparing the program identification and player identification may be for instance logic circuit comparators comparing two sets of parallel bits. Alternatively, the comparison (and other functions described herein) may be carried out by equivalents such as a control program executed by the microprocessor typically present in disc players. In this case the microprocessor control program would take the two serial streams and perform a conventional bit-by-bit comparison.

Each of comparators 90 and 94 provides, for instance, a high output if the comparison is a match i.e., the input data on the two inputs are identical. Similarly, each comparator 90 and 94 provides a low output signal if the inputs fail to match.

The output signals of comparators 90 and 94 are then provided to an AND gate 102. Thus only if the output signals from both comparator 90 and comparator 94 are high does AND gate 102 provide a high output signal. The output signal from AND gate 102 is the

first input to an OR gate 106. The second input to OR gate 106 is the authorization bit. Thus if this is a disc for sale, OR gate 106 receives a high input from the authorization bit. If the disc 14 is a rental disc, the authorization bit is 0 and the output of OR gate 106 is controlled by the output of AND gate 102. OR gate 106 then provides a play enable signal to, for instance, player electronics 66 (or to any other operating portion of the player) to enable operation thereof. Thus only if the output signal from OR gate 106 is high will the player be enabled for operation, i.e. playing of the program portion of the disc 14. This enablement function can take any one of a number of forms in terms of which portions of the player are enabled.

Thus it is to be understood that for a rental disc, only if the program identification recorded on the authorization medium of the disc matches the program identification on the optical portion of the disc, and additionally only if the player identification of the player matches the player identification recorded on the authorization medium, is the player operative for playing the disc. Thus the play enable signal, which is the output signal from OR gate 106, is needed to enable reading of any portions of the disc other than the initialization region.

Digital video disc players are sophisticated devices providing high speed digital signal processing i.e., have substantial embedded computing power. Thus it would be relatively inexpensive to include a small amount of additional program code to execute in software the functions illustrated in Figure 2 in the form of logic circuitry. Thus is to be understood that while Figure 2 shows a logic circuitry (hardware) embodiment, conversion of these functions to such a computer program is relatively simple and well within

the skill of one of ordinary skill in the art in the light of this disclosure.

Figure 3 shows a top view of a video disc 14 in accordance with the alternative embodiment of the invention. The video disc 14 includes a central hub region 112 which is used conventionally for mechanically holding the disc when being played. The optically recorded portion of the disc is the entire outer region 114 which contains optical tracks (not shown for clarity). The added element to such a disc in accordance with the present invention is the narrow magnetic track 118 which in this case immediately surrounds the hub region. Track 118 has a magnetic coating similar to that for instance of magnetic tape or a floppy disc, for conventional magnetic recording and reading. Magnetic track 118 accommodates only approximately 100 bytes of data and hence may be recorded at low density.

While the media referred to herein are digital video discs and video tapes, it is to be understood that this is not limiting. Other types of media are suitable such as a magneto-optical disc. The chief requirement is that the medium used in accordance with the invention have at least a small area suitable for recording (and subsequent rerecording) thereon by the TTRD.

Figure 4 shows a VHS video tape cassette in accordance with a second version of the alternative embodiment of the present invention. This video cassette is conventional in all respects except that located on an exterior of the housing is a magnetic track 124. In this case, magnetic track 124 is shown on a side surface. However, it may also be on the other side surface or on the top or bottom surfaces. In any case, the magnetic track is on a surface which, when the cassette is inserted into a VCR, moves past a

magnetic read head located inside the VCR for purposes of reading the data recorded on the track 124. A similar magnetic head mechanism is used for writing the track 124 in the TTRD. Track 124 may be relatively short and record at a relatively low data density since it again only involves approximately 100 bytes of data.

In this video cassette version, the information which in the video disc version is recorded on the optical portion of the disc is instead recorded on the video tape itself. This would be recorded e.g. on each frame or perhaps alternate frame in a convenient location so that the player can easily find this information without having to hunt for any particular location on the tape.

Also in the videotape cassette version there is a problem that the program content is of course readily altered by proper equipment. Thus it would be possible for a hacker to alter the rental control bit, i.e. alter a rental control bit from indicating rental to indicating this particular video cassette is intended for sale (not for rent). This is undesirable since it defeats the entire rental security system. To prevent this, the rental control bit, instead of standing alone, is the first bit in a block of data all of which is encrypted using a private key and decryptable by use of a public key stored in the particular VCR player. The rest of the data in the block is important picture or other data. This would prevent such alteration of the rental control bit.

Another version of the present system for video cassette tapes does not require provision of a magnetic recording area on the cassette housing or sprocket ends. Instead, a predetermined portion of the video tape is used for recording the encrypted program identification and player identification. This is less desirable since it would require rewinding of the tape

by the TTRD to find this particular predetermined area of the tape.

In the event that this rental control system is adopted by the DVD standards setting bodies, an issue arises with respect to universal manufacturer compliance. Since there is some added cost to each DVD player to implement this system, there is an incentive for any one particular manufacturer not to add the necessary circuitry and interface in order to gain a pricing advantage. The system as described herein does not require any special subsystem in a DVD player to allow rental discs (or tapes to play thereon.

If universal compliance cannot for some reason be obtained through contractual arrangements between all manufacturers, a technical method in accordance with the invention will assure compliance by each manufacturer. One method, compatible with the system described herein, is to encrypt a small but important segment of the programmed data on each disc with a special movie-dependent encryption key into a range for the matching decryption key to be delivered to the player from the TTRD, via the authorization card. Any encryption decryption system may be used herein. Therefore in order to be able to play rental discs, non-compliant DVD players would need to contain all of the subsystems as described herein needed by complying players and thus the owners of non-complying players would also have to have disc rental transactions processed by legitimate TTRDs. This should remove any incentives for manufacturers not to comply.

In another version of the system with reduced security but enhanced "user friendliness," there is no player identification provided. That is, all players are identical (generic) so far as security is concerned. Instead each player includes an electronic clock or equivalent which tracks the time and date, for

instance to the nearest hour, over the life of the product. Thus when the renter rents a disc, the TTRD at the rental store writes on the authorization card the movie identification and a rental date window, for instance 48 hours or 72 hours from the time of the rental.

Then when the renter takes the disc and the authorization card home and puts both into his player to play the disc, the control circuitry in the player compares the movie identification from the disc to that on the authorization card, and also compares the date window on the authorization card to the current date and time according to its internal clock. The disc will only then be played if the date matches the current data and time, and the player identification matches.

It is to be understood that the security in this version is less than that in the above described embodiments, since a hacker would be able to deduce the date window in the encrypted form and provide such a date window together with the movie identification in encrypted form without use of the authorized (legitimate) TTRD and write both of these pieces of information on the authorization card. However such hacker-type authorization would only be good for the particular date window which the hacker had obtained in encrypted form, i.e. a specific 48 or 72 hours.

This disclosure is illustrative and not limiting; further modifications will be apparent to one skilled in the art in the light of the present disclosure and are intended to fall within the scope of the appended claims.

What is claimed:

1. A method for preventing playing of a prerecorded medium on an unauthorized player, the player including an authorization portion having a player identification stored therein, the method comprising the steps of:

prerecording on the medium a program identification associated with contents of the medium;

prior to playing the prerecorded medium on a particular player, authenticating the program identification associated with the contents of the medium and the player identification of the particular player;

providing an authorization player; and

recording the authenticated program identification and player identification on the authorization medium, thereby preventing playing the medium without use of the authorization medium.

2. The method of Claim 1, wherein the step of authenticating includes encrypting by a private key of a public key encryption system.

3. The method of Claim 1, wherein the authorization medium is a memory card adapted for connection to a connection on the particular player.

4. The method of Claim 1, wherein the medium is an optically recorded video disc, and wherein the authorization medium is a magnetic recording area located near a center of the disc.

5. The method of Claim 1, wherein the medium is a video tape cassette, and the authorization medium is a magnetic recording area located on the video cassette housing.

6. The method of Claim 1, wherein the step of recording includes magnetically recording, and wherein the authorization medium is a magnetic track on the medium and spaced apart from the prerecorded contents of the medium.

7. The method of Claim 1, further comprising the step of transmitting the program identification, accompanied by a time indication, to a remote location.

8. The method of Claim 1, further comprising, prior to the step of encrypting, reading the program identification from the medium.

9. The method of Claim 1, wherein the step of prerecording includes prerecording on the medium an authorization indication.

10. The method of Claim 9, wherein the authorization indication is concatenated with other data and encrypted.

11. The method of Claim 1, wherein the step of prerecording includes prerecording on the medium a key encryption number for the step of encrypting.

12. An apparatus for authorizing a prerecorded medium for play on an particular player, the player including an authorization portion having a player identification number stored therein, and the prerecorded medium having a contents portion including

prerecorded program material and including a program identification, the apparatus comprising:

a medium reader portion capable of reading from the contents portion of the medium;

an encryptor operatively connected to the medium reader portion, thereby receiving the program identification;

an input terminal for receiving a particular player identification, the input terminal also being operatively connected to the encryptor;

a memory storing an encryption key, the memory being connected to the encryptor; and

a writing circuit adapted for writing on an authorization medium, the writing circuit receiving from the encryptor the program identification and the player identification in encrypted form and writing both on the authorization medium.

13. The apparatus of Claim 12, wherein the memory stores a plurality of encryption keys, each being a private key of a public key encryption system.

14. The apparatus of Claim 13, wherein each encryption key has a unique address in the memory, and further comprising means for receiving a memory address from the medium reader portion and selecting from the memory an encryption key corresponding to the received memory address.

15. The apparatus of Claim 12, wherein the writing circuit writes to a memory card adapted for connection to the writing circuit.

16. The apparatus of Claim 12, wherein the medium reader portion is an optical video disc reader, and

wherein the writing circuit records on an authorization area located near a center of the optical video disc.

17. The apparatus of Claim 12, further comprising a transaction reporting portion connected to the medium reader portion, and receiving the program identification therefrom.

18. The apparatus of Claim 16, wherein the writing circuit includes:

a coder portion connected to the encryptor;

an amplifier connected to the coder portion; and

a magnetic recording head connected to the coder and positioned adjacent the authorization area of the medium.

19. A method for authorizing playing of a prerecorded medium on a player, the prerecorded medium having a contents portion including prerecorded program contents, a program identification, and a decryption key, the method comprising the steps of:

reading from the contents portion the program identification and the decryption key;

reading from an authorization medium an encrypted program identification and player identification;

decrypting the program identification and the player identification read from the authorization medium;

comparing the decrypted program identification and player identification to respectively a player identification stored in the player and to the program identification read from the contents portion; and

if both comparisons indicate a match,

enabling operation of the player to play the prerecorded medium.

20. The method of Claim 19, wherein the decryption key is a public key of a public key encryption system.

21. The method of Claim 19, wherein the authorization medium is a memory card adapted for connection to the player.

22. The method of Claim 19, the contents portion of the prerecorded medium including an authorization indication, and further comprising the step of enabling operation of the player if the authorization indication so indicates.

23. The method of Claim 19, wherein the authorization indication is encrypted together with other information, and further comprising the step of decrypting the authorization indication.

24. The method of Claim 19, wherein the prerecorded medium is an optical video disc, and the step of reading from the authorization medium includes reading magnetically from an authorization area near a center of the optical video disc.

25. The method of Claim 19, wherein the prerecorded medium is a video tape cassette, and the step of reading from the authorization medium includes reading from an authorization area on the tape cassette housing as the cassette is inserted into the player.

26. A player for playing recorded media, each medium having a content portion including prerecorded

program contents, a program identification, and a decryption key, the player comprising:

a prerecorded medium reader portion;

a control portion connected to the medium reader to receive therefrom the decryption key and the program identification;

a reading circuit adapted for reading from an authorization medium;

a decryptor connected to the reading circuit and to the control portion, providing a program identification and a player identification read from the authorization medium in decrypted form to the control portion;

a first comparator connected to the decryptor and to the control portion, thereby comparing the decrypted program identification to the program identification from the content portion of the medium;

a memory storing the player identification;

a second comparator connected to the decryptor and to the memory, thereby comparing the decrypted player identification to the player identification stored in the memory; and

logic connected to the first and second comparators, providing a signal enabling playing of the program contents of the medium if both comparators indicate a match.

27. The player of Claim 26, wherein the decryption key is a public key of a public key encryption system.

28. The player of Claim 26, wherein the contents portion of the prerecorded medium includes an authorization indication, and wherein the control portion includes an enablement element providing a

signal enabling playing of the program contents of the prerecorded medium in response to the authorization indication.

29. The player of Claim 28, wherein the authorization indication is also encrypted, and further comprising, in the control circuit, means for decrypting the authorization indication.

30. The player of Claim 26, wherein the authorization medium is a memory card, and the reading circuit is adapted for connection to the memory card.

31. The player of Claim 26, wherein the prerecorded medium is an optical video disc, and the reading circuit includes a magnetic head positioned adjacent a center of the video disc when the video disc is in the player, the authorization medium being at the center of the video disc.

32. The player of Claim 26, wherein the prerecorded medium is a video tape cassette and the authorization medium is on an outside surface of the video tape cassette, and wherein the reading circuit includes a magnetic reading head positioned to read the authorization medium as the video tape cassette is inserted into the player.

33. The player of Claim 26, the reading circuit including:

a magnetic head;

an amplifier connected to the magnetic head;

a data decoder connected to the amplifier; and

an error correction portion connected to the data decoder.

34. A method for authorizing playing of a prerecorded medium on a player, the prerecorded medium having a contents portion including prerecording program contents, a program identification and a decryption key, the method comprising the steps of:

reading from the contents portion the program identification and the decryption key;

reading from an authorization medium an encrypted program identification and time window;

decrypting, using the decryption key, the program identification and the time window from the authorization medium;

comparing the decrypted program identification and time window to respectively the program identification read from the contents portion and a time kept by the player; and

if both comparisons indicate a match, enabling operation of the player to play the prerecorded medium.

35. A player for playing recorded media, each medium having recorded thereon program identification in encrypted form, a content portion including precorded program contents, and a decryption key, the player comprising:

a prerecorded medium reader portion;

a control portion connected to the medium reader to receive therefrom the decryption key and the program identification;

a reading circuit adapted for reading an authorization medium having the program identification and a time window written thereon in encrypted form;

a decryptor connected to the reading circuit and to the control portion, providing the program identification and time window in decrypted form;

a first comparator connected to the decryptor and to the control portion, thereby comparing the decrypted program identification to the program identification from the content portion;

a clock;

a second comparator connected to the decryptor and to the clock, thereby comparing the decrypted time window to a time indicated by the clock; and

logic connected to the first and second comparators, providing a signal enabling playing of the program contents of the prerecorded medium if both comparators indicate a match.

36. A video disc, comprising:

an optically recorded content portion including prerecorded video material and an initialization region, the initialization region including a data decryption key, a program identification identifying the prerecorded video material, and a play authorization indication; and

a magnetic track, the magnetic track being at a predetermined location on the disc relative to the optically recorded content portion, the magnetic track including sufficient area to record the program identification and a player number.

37. A video tape cassette, comprising:

a cassette housing;

a length of video tape mounted on two spindles inside the housing; wherein recorded on the tape, in addition to prerecorded video material, are a data decryption key and a program identification of the prerecorded video material; and

fixed on one of two locations, selected from

a group consisting of an exterior of the housing and an end of one of the spindles, is a magnetic recording track of a length sufficient to record the program identification and a player identification.

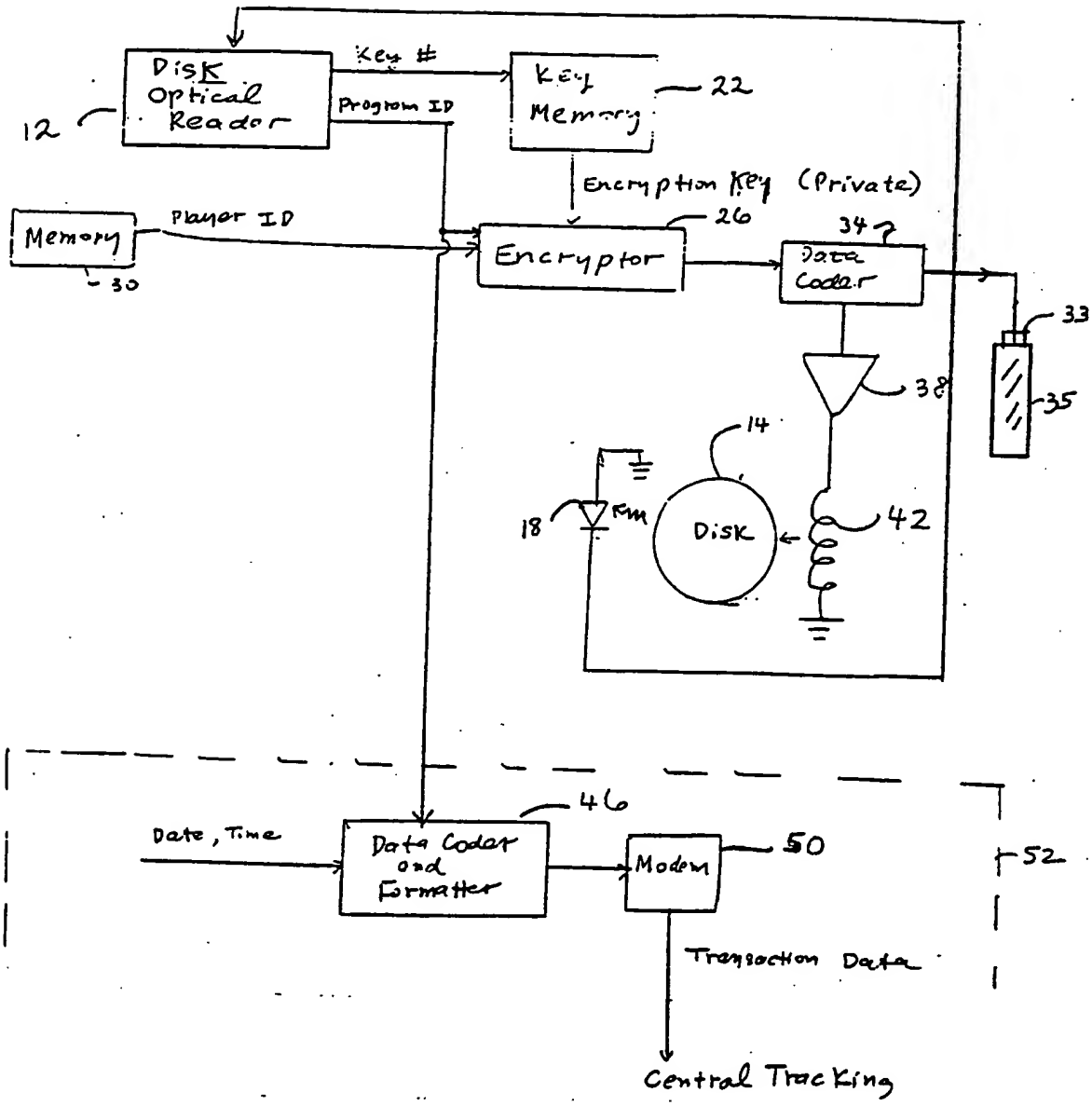
Disk Optical Reader
12
Key #
Program ID
Key Memory
22
Encryption Key (Private)
Memory
Player ID
30
Encryptor
26
34
Data Coder
33
35
38
14
18
FM
Disk
42
46
Date, Time
Data Coder and Formatter
Modem
50
52
Transaction Data
Central Tracking

Fig. 1

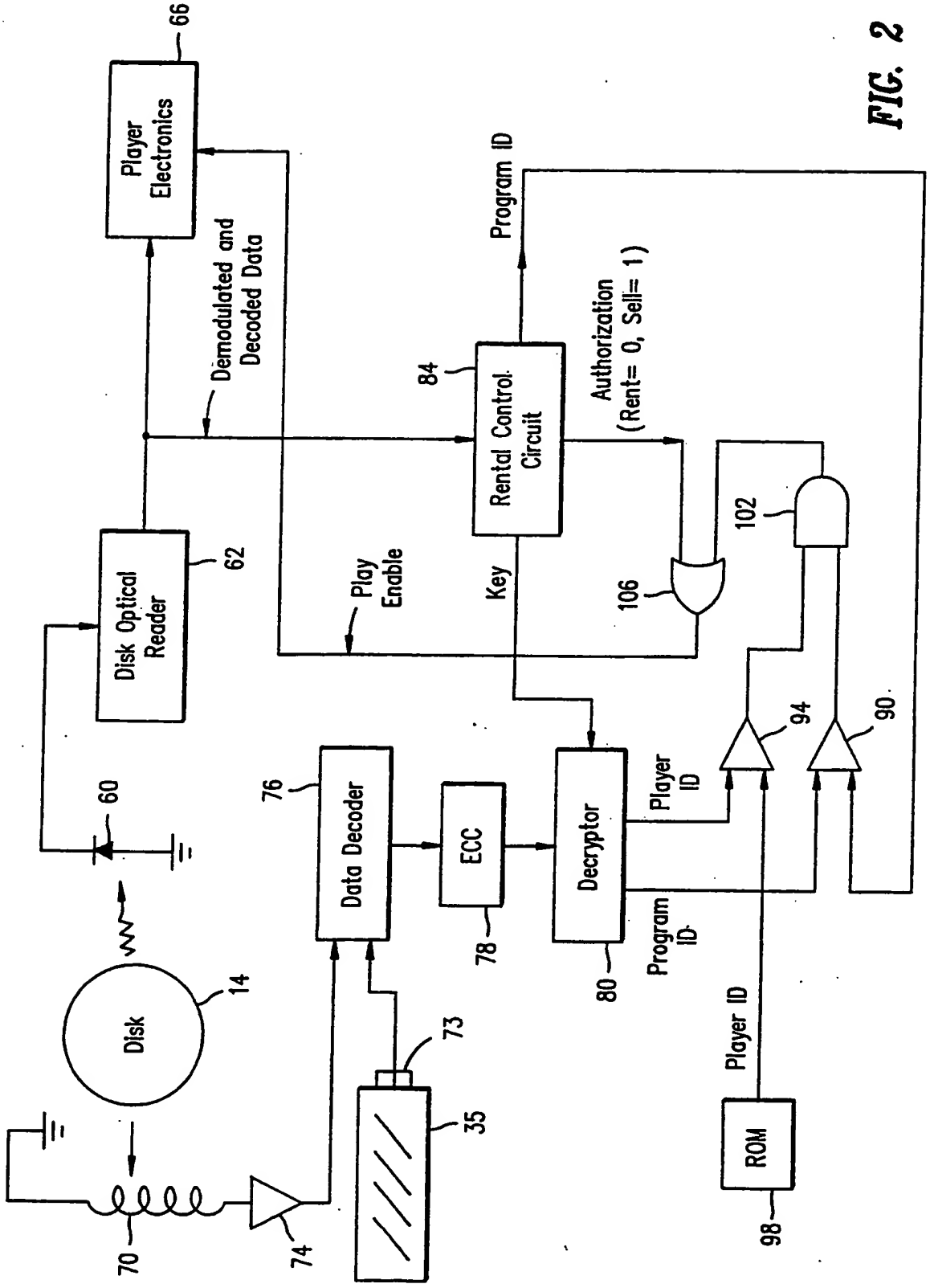
66
Player Electronics
Demodulated and Decoded Data
Program ID
84
Rental Control Circuit
Authorization (Rent= 0, Sell= 1)
102
106
Play Enable
Key
62
Disk Optical Reader
60
76
Data Decoder
ECC
78
Decryptor
80
Player ID
Program ID
94
90
Disk
14
73
35
70
74
ROM
98
Player ID

FIG. 2

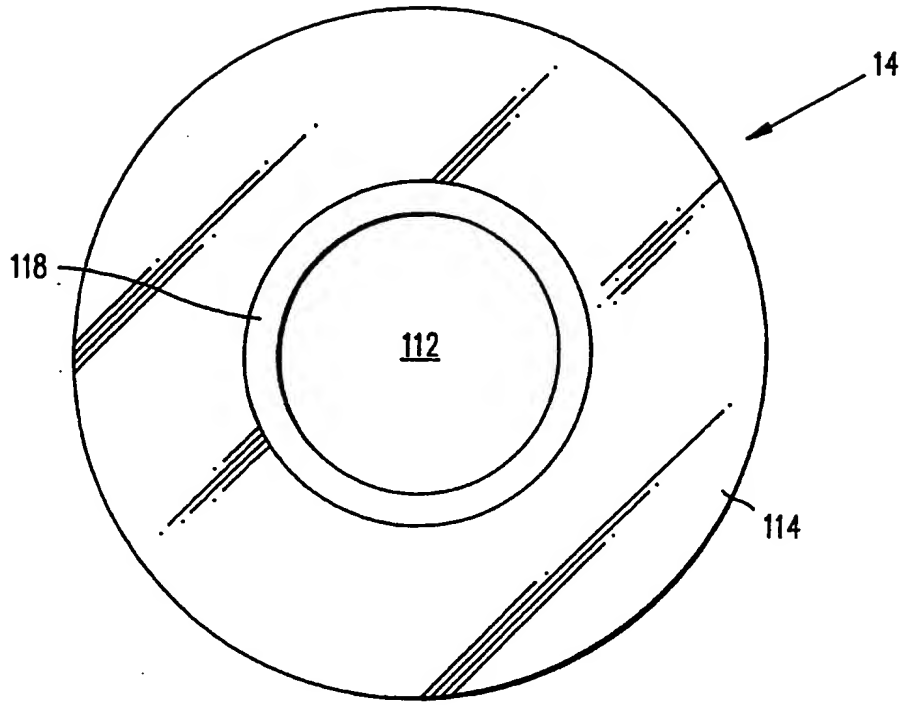

FIG. 3

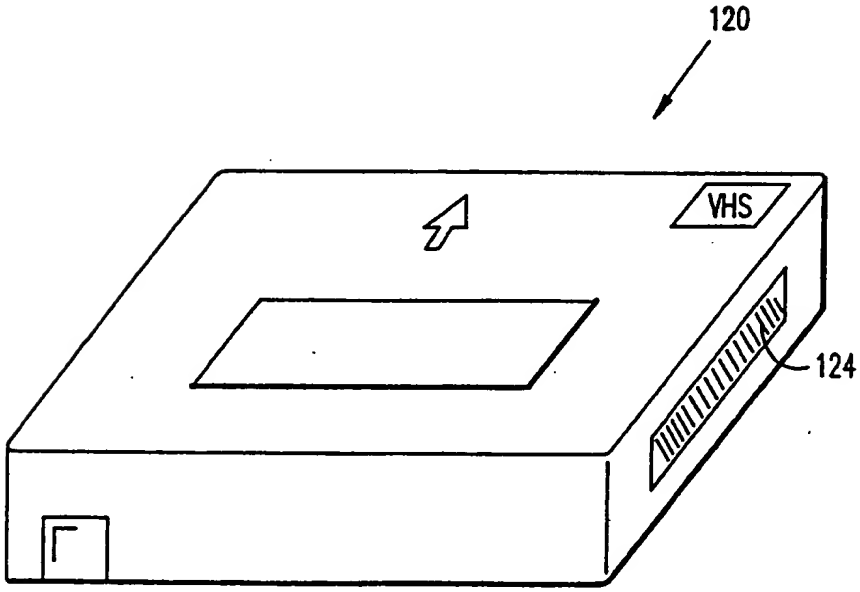

FIG. 4

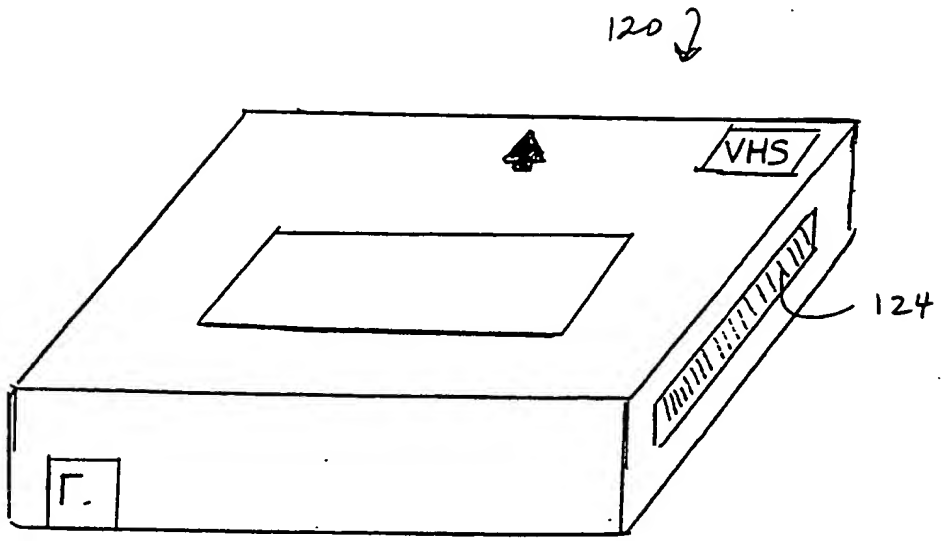

Fig. 4

INTERNATIONAL SEARCH REPORT

Im ational application No.
PCT/US96/08354

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 380/3, 4, 5, 23, 25; 360/33.1, 60, 132, 133, 134, 135; 369/48, 58, 59; 358/310, 335; 340/825.31, 825.34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y -- A	US, A, 4,866,769 (KARP) 12 September 1989, the whole document.	1, 8, 9, 11 --- 2-7, 10, 12-18,19-25, 26-33, 36, 37 --- 34, 35
Y -- A	US, A, 4,453,073 (WEINSTEIN) 05 June 1984, the whole document.	10, 12-18, 19-25, 26-33 --- 34, 35
Y, P	US, A, 5,450,489 (OSTROVER ET AL.) 12 September 1995, the Abstract.	2

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 22 AUGUST 1996	Date of mailing of the international search report 04 OCT 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HRAYR A. SAYADIAN Telephone No. (703) 306-4169

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

Int. ational application No.
PCT/US96/08354

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,267,311 (BAKHOUM) 30 November 1993, Fig. 1(b) Element # 110 and the Figs. accompanying text.	3, 21, 30
Y	US, A, 5,379,433 (YAMAGISHI) 03 January 1995, the whole document.	4, 6, 16, 18, 24, 31, 36
Y	US, A, 5,400,319 (FITE ET AL.) 21 March 1995, the whole document, as well as line 61 of column 16 to line 5 of column 17.	4, 6, 16, 18, 24, 31
Y	US, A, 4,991,208 (WALKER ET AL.) 05 February 1991, the whole document, see also lines 17-22 of column 2.	5, 25, 32, 33, 37
Y	EP, A, 0,393,955 (SONY) 24 October 1990, the whole document.	5, 25, 32, 33, 37
Y	WO, A, 89/10615 (BRITISH BROADCASTING CORPORATION) 02 November 1989, the whole document.	5, 25, 32, 33, 37
Y	US, A, 5,400,403 (FAHN ET AL.) 21 March 1995, the whole document.	7

INTERNATIONAL SEARCH REPORT

Int...ational application No.
PCT/US96/08354

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/08354

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

G06F 7/04; G07D 7/00; G11B 5/78, 5/82, 3/90, 5/09, 15/04, 15/52, 19/04, 20/12, 23/02, 23/03, 23/28, 27/22, 27/36; H04K 1/00; H04L 9/00; H04N 9/79, 5/76, 5/78, 7/167

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

380/3, 4, 5, 23, 25; 360/33.1, 60, 132, 133, 134, 135; 369/48, 58, 59; 358/310, 335; 340/825.31, 825.34

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack Unity of Invention because they are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for more than one species to be examined, the appropriate additional examination fees must be paid. The species are as follows:

Group I:Claims 1-18, directed to Fig. 1.
Group II:Claims 19-33, directed to Fig. 2.
Group III:Claims 34 and 35, detailed specification does not seem to describe these claims. These claims, however, address subject matter that are mutually exclusive from claims 19-33.
Group IV:Claim 36, directed to Fig. 3.
Group V:Claim 37, directed to Fig. 4.

The species listed above do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, the species lack the same or corresponding special technical features for the following reasons: Group I is a process or device for making, Group II is a process or device for using, Group III is a process or device for using that uses subject matter exclusively different than Group II, Group IV is a specific device that is different than the inventions of Groups I-III, and Group V is a specific device that is different than the invention of Groups I-IV.

(19) RÉPUBLIQUE FRANÇAISE

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(12) DEMANDE DE CERTIFICAT D'ADDITION A UN BREVET D'INVENTION A2

(22) **Date de dépôt** : 24.08.89.

(30) **Priorité** :

(43) **Date de la mise à disposition du public de la demande** : 01.03.91 Bulletin 91/09.

(56) **Liste des documents cités dans le rapport de recherche** : *Se reporter à la fin du présent fascicule.*

(60) **Références à d'autres documents nationaux apparentés** : certification d'addition au brevet 8901390 depose le 030289

(71) **Demandeur(s)** : *URBA 2000 Association déclarée de droit français* — FR.

(72) **Inventeur(s)** : Ricci Bruno et Vallet Erik.

(73) **Titulaire(s)** :

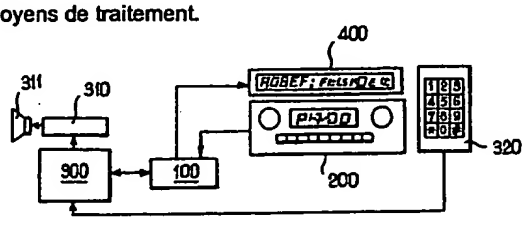
(74) **Mandataire** : Cabinet Dupuis Latour.

(54) Circuit d'interfaçage pour récepteur d'informations radiodiffusées de guidage pour automobilistes.

(57) L'invention concerne un circuit d'interfaçage pour la mise en œuvre d'un système dans lequel une séquence défilante d'informations est diffusée par voie hertzienne par un procédé tel que le RDS.

Ce circuit (100) est relié à l'autoradio (200) et à des moyens (300) de traitement numérique des données, et comprend un premier étage recevant en entrée, en provenance de l'autoradio, d'une part un signal d'horloge et d'autre part les informations de signal numérique sous forme d'un flux série de données synchrone et délivrant en sortie ces mêmes informations de signal numérique sous forme d'un flux de données parallèle asynchrone, ce premier étage comprenant deux registres à décalage semblables et des moyens de commande opérant de telle sorte que les registres soient chargés successivement et alternativement par des portions du flux de données synchrone, le contenu de l'un des registres étant, après achèvement du chargement, lu sous forme parallèle pendant que l'autre registre est en cours de chargement, et inversement, les informations en sortie de ce premier étage étant ensuite décodées et discriminées par les moyens de traitement délivrant à des moyens d'affichage (400) des signaux correspondants.

Très avantageusement, le circuit comprend en outre un second étage recevant en entrée le flux de données parallèle asynchrone délivré par le premier étage (110) et délivrant en sortie un flux de données série asynchrone contrôlé aux normes RS-232C pour émission vers les moyens de traitement.



FR 2 651 352 - A2

Circuit d'interfaçage pour récepteur d'informations radiodiffusées de guidage pour automobilistes

La présente addition concerne un perfectionnement au système de collecte et de diffusion d'informations pour automobilistes décrit dans le brevet principal 89-01390.

Ce brevet proposait en particulier d'émettre une séquence défilante d'informations diffusée par voie hertzienne par un procédé de diffusion de données numériques à sous-porteuse ajoutée à un signal d'émission de radiodiffusion, les récepteurs à bord des véhicules étant des récepteurs de radiodiffusion équipés d'un décodeur assurant la séparation des informations de signal numérique d'avec le signal de programme audio.

Un système caractéristique de diffusion des données numériques par un tel procédé est le système RDS (*Radio Data System*), qui autorise la diffusion de données numériques par radio en modulation de fréquence conformément à un certain nombre de spécifications bien définies.

Comme on l'avait mentionné au brevet principal, l'un des intérêts majeurs du système RDS est de pouvoir être utilisé par de simples autoradios équipées d'un décodeur approprié, et dont divers modèles sont actuellement disponibles ou en cours de développement.

Pour utiliser les informations de guidage diffusées par le système du brevet principal, il suffit alors de relier à la sortie de données numériques de l'autoradio un boîtier comportant les circuits et moyens de commande appropriés.

La présente addition a précisément pour objet un circuit d'interfaçage permettant d'adapter les signaux délivrés par l'autoradio et de mettre en oeuvre les fonctions appropriées par des moyens simples.

Plus précisément, l'un des buts de la présente addition est de proposer un circuit d'interfaçage qui permette de faire exécuter la totalité des fonctions logicielles nécessaires par des moyens préexistants tels qu'un circuit à microcalculateur couram-

ment disponible ou un micro-ordinateur « compatible » du commerce, éventuellement simplifié pour n'en conserver que les éléments essentiels (carte logique).

Très avantageusement, le circuit d'interfaçage de l'invention comportera également des moyens permettant, à partir de signaux délivrés par le microcalculateur, de piloter un afficheur tel qu'une barrette de caractères alphanumériques à cristaux liquides.

On voit ainsi que seul le circuit d'interfaçage de l'invention sera spécifique, la totalité des autres éléments (autoradio, microcalculateur et afficheur) étant des éléments standards disponibles dans le commerce et produits en grande série, donc de très bas coût.

Par ailleurs, on verra que, dans un mode de réalisation préférentiel, le circuit d'interfaçage de l'invention communique suivant la norme RS-232C avec le microcalculateur (en émission vers celui-ci pour lui transférer les données brutes à traiter, et en réception pour recevoir les données à présenter sur l'afficheur) ; cette norme est une norme d'usage universel, qui permettra donc de faire coopérer le circuit d'interfaçage de l'invention et son autoradio associé avec une très grande variété de microcalculateurs sans nécessiter aucune adaptation particulière du circuit, les seules adaptations étant des adaptations logicielles internes au microcalculateur et donc aisées à mettre en oeuvre.

Selon l'invention, le circuit est caractérisé en ce qu'il est relié à l'autoradio et à des moyens de traitement numérique des données et en ce qu'il comprend un premier étage recevant en entrée, en provenance de l'autoradio, d'une part un signal d'horloge et d'autre part les informations de signal numérique sous forme d'un flux série de données synchrone séquencé sur ce signal d'horloge et délivrant en sortie ces mêmes informations de signal numérique sous forme d'un flux de données parallèle asynchrone, ce premier étage comprenant deux registres à décalage semblables et des moyens de commande opérant de telle sorte que les registres soient chargés successivement et alternativement par des portions du flux de données synchrone, le contenu de l'un des registres étant, après

achèvement du chargement, lu sous forme parallèle pendant que l'autre registre est en cours de chargement, et inversement, les informations en sortie de ce premier étage étant ensuite décodées et discriminées par les moyens de traitement délivrant aux moyens d'affichage des signaux correspondants.

Très avantageusement, le circuit d'interfaçage comprend en outre un second étage recevant en entrée le flux de données parallèle asynchrone délivré par le premier étage et délivrant en sortie un flux de données série asynchrone contrôlé aux normes RS-232C pour émission vers les moyens de traitement.

Dans ce cas, de préférence, le second étage reçoit en outre en entrée, depuis les moyens de traitement, un flux de données série aux normes RS-232C et transforme ce flux série reçu en un flux parallèle propre à contrôler les moyens d'affichage.

◊

On va maintenant donner un exemple détaillé de réalisation de l'invention, en référence aux dessins annexés.

La figure 1 est une vue schématique d'ensemble du circuit d'interfaçage de l'invention et des différents organes avec lesquels il coopère.

La figure 2 est une représentation schématique interne du circuit d'interfaçage de l'invention montrant les deux étages utilisés et les différents connecteurs.

La figure 3 est un chronogramme montrant l'évolution dans le temps des divers signaux de commande produits par le premier étage du circuit d'interfaçage de l'invention.

La figure 4 montre le détail des éléments constituant le premier étage du circuit d'interfaçage de l'invention.

La figure 5 montre le détail des éléments constituant le second étage du circuit d'interfaçage de l'invention.

◊

La figure 1 est une vue générale de l'ensemble des éléments permettant la réception et l'affichage des informations de guidage constituant la partie de réception, montée à bord des véhicules, du système de diffusion d'informations de guidage exposé au brevet principal, auquel on se reportera pour de plus amples détails.

Cet ensemble s'organise autour d'un circuit d'interfaçage spécifique 100 qui fait l'objet de la présente invention ; ce circuit 100 reçoit des informations en provenance de la sortie de données numériques (« voies de données à utilisation externe » dans la terminologie de la norme RDS) d'une autoradio 200, qui est une autoradio du commerce, non modifiée, équipée de circuits RDS permettant d'assurer la séparation entre des données audio et des données numériques transmises simultanément par une même station de radiodiffusion.

Le circuit d'interfaçage 100 émet et reçoit des données en direction et en provenance de moyens de traitement 300, qui peuvent être constitués d'un micro-ordinateur classique (par exemple de type dit « compatible »), non modifié ou bien simplifié pour n'en conserver que les éléments essentiels (carte logique uniquement, c'est-à-dire comprenant l'unité centrale, les mémoires vive et morte et leurs circuits de commande, les circuits permettant de communiquer avec le monde extérieur) ; les moyens de calcul 300 peuvent être également constitués d'une carte comportant un circuit microcalculateur de type classique, architecturé également de façon classique.

Les moyens de calcul 300 peuvent avantageusement être reliés à un circuit de synthèse vocale 310 délivrant des messages directement perceptibles par le conducteur sur un haut-parleur 311.

Les informations de guidage routier ou urbain sont également affichées sur un afficheur 400, par exemple une barrette de caractères alphanumériques à cristaux liquides, piloté de préférence par des signaux délivrés par les moyens de calcul 300 via le circuit d'interfaçage 100 (ce circuit agissant alors en réception vis-à-vis des moyens de calcul 300).

Les données de paramétrage par le conducteur (choix de

l'itinéraire, demande de situation pour un noeud de circulation particulier, etc.) sont introduites directement dans les moyens de calcul 300 par exemple par un pavé numérique 320.

La figure 2 montre de façon schématique la structure interne du circuit d'interfaçage 100. Celui-ci comprend essentiellement deux étages 110, 120 et trois connecteurs 111, 121 et 122.

Le rôle du premier étage 110 est essentiellement de recevoir, via le connecteur 111, le flux de données en provenance de l'autoradio 200 et de transformer ces données, qui arrivent sous forme d'un flux de données série synchrone en un flux de données parallèle asynchrone sur un bus 115.

Le second étage 120 assure deux fonctions.

En premier lieu, il reçoit le flux de données parallèle asynchrone produit par le premier étage 110 et transforme ce flux en un flux de données série asynchrones aux normes RS-232C pour émission vers les moyens de calcul 300.

En second lieu, il reçoit des moyens de calcul 300 des signaux aux normes RS-232C qui correspondent aux seules informations devant être délivrées au conducteur, c'est-à-dire après filtrage, correction d'erreur et discrimination ; l'étage 120 convertit ce flux de données série RS-232C en signaux parallèles appliqués, via le connecteur 122, aux différentes bornes de l'afficheur 400 en assurant les adaptations nécessaires pour que ces signaux soient rendus compatibles avec les entrées de l'afficheur 400.

On va maintenant décrire en détail la structure des deux étages 110 et 120, respectivement en référence aux figures 4 et 5.

Le premier étage 110, illustré de façon simplifiée figure 4 (seuls ont été représentées les lignes correspondant aux différents signaux logiques produits, abstraction faite des lignes de masse, d'alimentation, etc.).

Cet étage reçoit de l'autoradio, par le connecteur 111, d'une part un signal CLK qui est le signal de l'horloge associé au signal RDS et dont la fréquence est de 1187,5 Hz (c'est-à-dire la fréquence de la sous-porteuse RDS, 57 kHz, divisée par 48), et d'autre part un signal DATA qui constitue l'information RDS

proprement dite. Conformément aux normes RDS, ce signal DATA est un signal logique dont la valeur (0 ou 1) pourra changer durant le flanc montant du signal CLK ; les deux signaux CLK et DATA sont des signaux compatibles TTL (le zéro logique correspondant à zéro volt et le un logique correspondant à cinq volts) qui peuvent donc directement attaquer les différents circuits de l'étage 110.

L'étage 110 va transformer le signal série DATA à 1187,5 bits/s, synchrone avec le signal CLK, en une information parallèle sur huit bits, asynchrone, sur un bus interne 50.

Du fait du fonctionnement asynchrone, il serait normalement impossible de garantir que l'ensemble des informations RDS disponibles en sortie de l'autoradio seront émises sans perte sur le bus 115 puis vers les moyens de calcul.

Afin de remédier à cet inconvénient, l'étage 110 prévoit deux circuits semblables 113, 114 et 113', 114', respectivement, commandés par un circuit 112 assurant le basculement entre ces deux circuits semblables. L'étage 110 pourra donc, simultanément, recevoir l'information RDS et la transférer sur le bus 115 sans perte, les deux circuits semblables fonctionnant en mode « double tampon » ou « ping-pong ».

Plus précisément, les données arrivant sur la borne DATA du connecteur 111 sont appliquées à chacune des entrées de données de deux registres à décalage 113, 113' (par exemple, des *HC 164*) délivrant en sortie huit bits simultanés appliqués à un registre tampon respectif 114, 114' (par exemple, des *HC 241*) dont les sorties sont reliées à un bus commun 115. Les registres à décalage 113, 113' et les tampons 114, 114' sont contrôlés par un circuit de commande 112 recevant en entrée le signal CLK d'horloge RDS et délivrant en sortie aux registres à décalage 113, 113' des signaux d'horloge modifiés CLK1 et CLK2 (illustrés sur le chronogramme de la figure 3) et aux tampons 114, 114' des signaux de commande Q et Q/.

Comme on peut le voir sur le chronogramme de la figure 3, le signal d'horloge CLK est tout d'abord divisé par huit par le diviseur IC1 (par exemple, un *HC 161*) ; ce signal divisé, ainsi que son

signal complémenté correspondant, sont ensuite ajoutés logiquement au signal CLK pour produire les signaux CLK1 et CLK2 appliqués respectivement aux registres à décalage 113 et 113'.

On voit ainsi que, pendant une période de huit impulsions d'horloge, on assurera le séquencement du registre à décalage 113 mais non celui du registre à décalage 113', et inversement pendant la période suivante de huit impulsions d'horloge.

Pendant que l'un des registres à décalage (par exemple, le registre à décalage 113) est séquencé, et donc en cours de chargement, l'autre registre (dans ce cas, le registre 113') est lu en sortie par l'intermédiaire de son étage tampon (ici, 114') qui est alors activé par les signaux Q et Q/ produits également par le circuit 112 : la séquence de huit bits qui avait été chargée dans le registre à décalage 113 au cours de la période de huit impulsions d'horloge immédiatement précédente est ainsi appliquée, en parallèle, sur le bus 115 ; pendant ce temps le tampon 114, dont les entrées de commande Q et Q/ sont inversées par rapport à celles du tampon 114',verra sa sortie mise en haute impédance pour ne pas perturber le fonctionnement de l'autre registre 114' et donc les informations appliquées sur le bus 115 (les sorties des tampons 114, 114' sont des sorties en logique « trois états »).

Les différents circuits IC1 à IC5 constituant le circuit de commande 112 sont des bascules et inverseurs en eux-mêmes classiques (par exemple IC1 : *HC 161*, IC2 : *HC 138*, IC3 : *HC 74*, IC4 : *HC 04* et IC5 : *HC 08*) configurés de manière à produire les différents signaux de commande CLK1, CLK2, Q et Q/ suivant la séquence expliquée plus haut ; la combinaison des différents circuits résulte de manière directe des fonctions propres de ceux-ci et ne sera pas décrite dans le détail.

La figure 3 montre le détail du second étage 120.

La fonction première de ce second étage 120 est de transformer les données parallèles présentes sur le bus interne 115 en données série transmises vers des moyens de calcul extérieurs 300 conformément à la norme universelle RS-232C via le connecteur 121.

A cet effet, on utilise un circuit UART (*Universal Asynchronous Receiver-Transmitter* : émetteur/récepteur asynchrone universel) 123, par exemple un *AY3-1015* configuré de manière appropriée, de manière à délivrer sur une borne TXD (*Transmit Data* : émission de données) un flux de données série asynchrone à une cadence déterminée par une base de temps 124 réglée à une fréquence compatible avec les possibilités des moyens de traitement 300, par exemple une cadence de 9600 bits/secondes.

L'UART 123 est paramétré par un jeu de commutateurs 125 permettant de déterminer le nombre de bits renvoyé (5,6,7 ou 8), l'existence ou non d'un contrôle de parité et, si tel est le cas, le caractère pair ou impair de la parité).

L'autre fonction de l'étage 120 est de recevoir des données en provenance des moyens de calcul 300, également sous forme d'un flux série à la norme RS-232C, et de transformer ce flux série en données parallèles permettant, via le connecteur 122, de commander l'afficheur à cristaux liquides.

On utilise le même circuit UART 123, mais fonctionnant en récepteur de signaux ; les signaux reçus sur la borne RXD (*Receive Data* : réception des données) du connecteur 121 sont adaptés en niveau et en impédance par un étage 126 et appliqués directement à l'UART 123, qui délivre directement en sortie, sur ses bornes RD0 à RD7, les huit bits servant à l'affichage des données. Ces huit bits comprennent par exemple quatre bits de données (un octet étant alors transféré en deux fois) et trois bits de contrôle, un bit restant inutilisé. Ces signaux sont appliqués directement à la barrette à cristaux liquides via un simple tampon 128 (par exemple, un *74LS241*).

L'UART 123, et donc le circuit d'interfaçage de l'invention, peut fonctionner soit de façon autonome soit sous le contrôle des moyens de calcul 300.

Dans ce dernier cas, on utilise les signaux CTS (*Clear To Send* : prêt à émettre) et RTS (*Request To Send* : demande d'émission) de la norme RS-232C. Le signal CTS, reçu en provenance des moyens de calcul 300, et le signal RTS, émis en direction des moyens

de calcul 300, sont gérés à l'égard de l'UART 123 par un circuit 127 ; ce circuit est, en lui-même, d'un schéma classique préconisé pour un UART de type *AY3-1015*, et on ne le décrira donc pas en détail.

On notera simplement que, pour le mettre en service, il sera nécessaire d'ouvrir la connexion 129, qui permet d'assurer la commutation entre un fonctionnement autonome de l'étage 120 (liaison 129 établie) et un fonctionnement non autonome, avec échange des signaux RTS et CTS (liaison 129 supprimée) sous le contrôle des moyens de calcul 300.

On va maintenant décrire brièvement la manière dont les signaux transmis par le circuit d'interfaçage de l'invention aux moyens de calcul sont traités par ces derniers.

On notera que l'ensemble des fonctions logicielles est exécuté par ces moyens de calcul, et donc que le circuit d'interfaçage de l'invention — qui est le seul sous-ensemble spécifique de l'ensemble de réception — est chargé de l'exécution de seules fonctions matérielles, ce qui permet d'en réduire d'autant le coût et la complexité.

Préalablement, les moyens de calcul dialoguent avec le conducteur en posant sur l'afficheur un certain nombre de questions auxquelles le conducteur pourra répondre en appuyant sur les touches d'un pavé numérique 320. On pourra notamment répertorier les différents noeuds de circulation importants par des codes numériques donnés par une carte ou une table mise à disposition du conducteur.

Par exemple, le conducteur pourra demander la sélection des informations correspondant à un itinéraire donné en indiquant le point de départ et le point d'arrivée (les moyens de calcul se chargeant alors de déterminer les tronçons et noeuds de circulation importants correspondants), ou bien introduire un numéro de tronçon ou de noeud de circulation unique pour obtenir les informations concernant ce seul point.

Après ce dialogue, les moyens de calcul vont effectuer le traitement proprement dit des signaux délivrés par le circuit

d'interfaçage 100.

Tout d'abord, dans le flot continu de données qui leur est transmis de manière asynchrone, ils vont effectuer une recherche du début de la trame et assurer un calage et une synchronisation sur celui-ci ; la norme RDS prévoit à cet effet, dans chaque bloc de 104 bits, quatre trames de 26 bits comprenant chacune 16 bits de données proprement dites et 10 bits de contrôle et de synchronisation configurés de façon bien précise. Ce sont ces bits de contrôle et de synchronisation que les moyens de calcul vont rechercher dans le flux ininterrompu de données qu'ils reçoivent, afin de pouvoir extraire les différents mots de données successifs de chaque trame RDS successive transmise.

On opère ensuite un contrôle d'erreur et, éventuellement, une correction lorsque celle-ci est possible (on utilise en effet des codes redondants de détection des erreurs).

On vérifie ensuite, d'après les informations d'identification de la station contenues dans le flux de données RDS, que l'on se trouve bien sur la bonne station, c'est-à-dire sur celle qui émet les données de guidage des automobilistes et non sur une autre station qui n'émet pas de telles données. En cas d'erreur, un message est appliqué à l'afficheur 400 pour demander au conducteur de modifier l'accord de son autoradio.

On opère ensuite le décodage spécifique proprement-dit : tout d'abord, on extrait du flux de données RDS les seules informations qui concernent le guidage, en filtrant toutes les autres informations systématiquement ou optionnellement transmises par le système RDS (nom de la station, fréquence des émetteurs les plus proches, identification en clair de l'émetteur, date et heure, informations de radiotexte, etc.).

Ensuite, parmi l'ensemble de ces données de guidage, on extrait les seules informations qui concernent le ou les tronçons ou noeuds de circulation préalablement sélectionnés au moment du dialogue avec le conducteur.

L'état des noeuds ou des tronçons ainsi sélectionnés est alors transmis en clair au conducteur sur l'afficheur 400 et/ou par

des moyens à synthèse vocale (circuit 310 de la figure 1) directement pilotés par les moyens de calcul 300.

On peut ainsi afficher l'identification en clair du tronçon ou du noeud de circulation, suivie de son état correspondant, également en clair ; par exemple, les états peuvent être : « fluide », « ralenti », « dense » ou « bouchon » (valeurs générées automatiquement par le système de collecte des données), « déconseillé » ou « interdit » (états forçables depuis un poste de commande), ou un état « non renseigné ».

De telles informations peuvent être aisément présentées sur un afficheur, d'un type couramment disponible, de 1 ou 2 lignes de 40 caractères alphanumériques.

REVENDICATIONS

1. Un circuit d'interfaçage pour la mise en oeuvre d'un système selon l'une des revendications du brevet principal, système dans lequel une séquence défilante d'informations est diffusée par voie hertzienne par un procédé de diffusion de données numériques à sous-porteuse ajoutée à un signal d'émission de radiodiffusion, les récepteurs à bord des véhicules étant des autoradios équipées d'un décodeur assurant la séparation des informations de signal numérique d'avec le signal de programme audio,

circuit (100) caractérisé en ce qu' il est relié au récepteur de radiodiffusion (200) et à des moyens (300) de traitement numérique des données, et en ce qu'il comprend un premier étage (110) recevant en entrée, en provenance de l'autoradio, d'une part un signal d'horloge (CLK) et d'autre part les informations de signal numérique (DATA) sous forme d'un flux série de données synchrone séquencé sur ce signal d'horloge et délivrant en sortie ces mêmes informations de signal numérique sous forme d'un flux de données parallèle asynchrone, ce premier étage comprenant deux registres à décalage (113, 113') semblables et des moyens de commande (112) opérant de telle sorte que les registres soient chargés successivement et alternativement par des portions du flux de données synchrone, le contenu de l'un des registres étant, après achèvement du chargement, lu sous forme parallèle pendant que l'autre registre est en cours de chargement, et inversement,

les informations en sortie de ce premier étage étant ensuite décodées et discriminées par les moyens de traitement délivrant à des moyens d'affichage (400) des signaux correspondants.

2. Le circuit d'interfaçage de la revendication 1, comprenant en outre un second étage (120) recevant en entrée le flux de données parallèle asynchrone délivré par le premier étage (110) et délivrant en sortie un flux de données série asynchrone (TXD) contrôlé aux normes RS-232C pour émission vers les moyens de traitement.

REVENDICATIONS

1. Un circuit d'interfaçage pour la mise en oeuvre d'un système selon l'une des revendications du brevet principal, système dans lequel une séquence défilante d'informations est diffusée par voie hertzienne par un procédé de diffusion de données numériques à sous-porteuse ajoutée à un signal d'émission de radiodiffusion, les récepteurs à bord des véhicules étant des autoradios équipées d'un décodeur assurant la séparation des informations de signal numérique d'avec le signal de programme audio,

circuit (100) caractérisé en ce qu' il est relié au récepteur de radiodiffusion (200) et à des moyens (300) de traitement numérique des données, et en ce qu'il comprend un premier étage (110) recevant en entrée, en provenance de l'autoradio, d'une part un signal d'horloge (CLK) et d'autre part les informations de signal numérique (DATA) sous forme d'un flux série de données synchrone séquencé sur ce signal d'horloge et délivrant en sortie ces mêmes informations de signal numérique sous forme d'un flux de données parallèle asynchrone, ce premier étage comprenant deux registres à décalage (113, 113') semblables et des moyens de commande (112) opérant de telle sorte que les registres soient chargés successivement et alternativement par des portions du flux de données synchrone, le contenu de l'un des registres étant, après achèvement du chargement, lu sous forme parallèle pendant que l'autre registre est en cours de chargement, et inversement,

les informations en sortie de ce premier étage étant ensuite décodées et discriminées par les moyens de traitement délivrant à des moyens d'affichage (400) des signaux correspondants.

2. Le circuit d'interfaçage de la revendication 1, comprenant en outre un second étage (120) recevant en entrée le flux de données parallèle asynchrone délivré par le premier étage (110) et délivrant en sortie un flux de données série asynchrone (TXD) contrôlé aux normes RS-232C pour émission vers les moyens de traitement.

3. Le circuit d'interfaçage de la revendication 2, dans lequel le second étage (120) reçoit en entrée, depuis les moyens de traitement, un flux de données série (RXD) aux normes RS-232C et transforme ce flux série reçu en un flux parallèle propre à contrôler les moyens d'affichage (400).

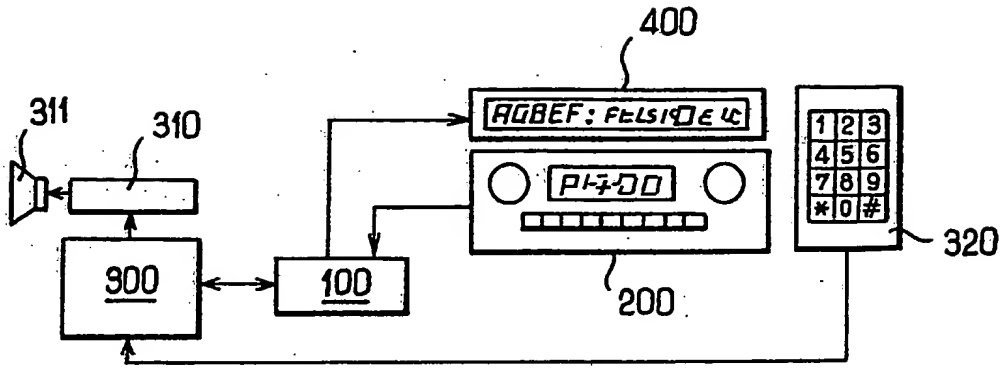


FIG_1

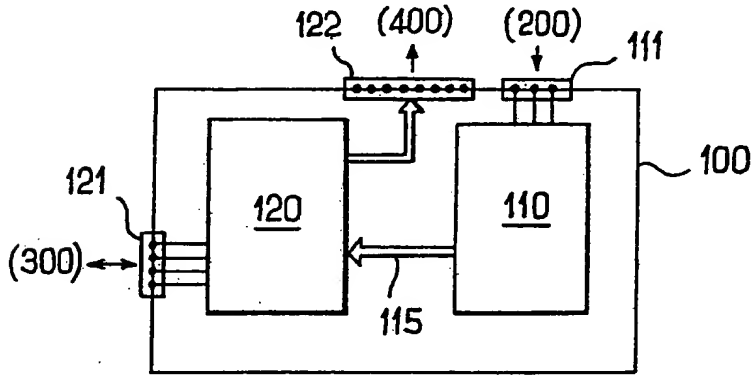


FIG_2

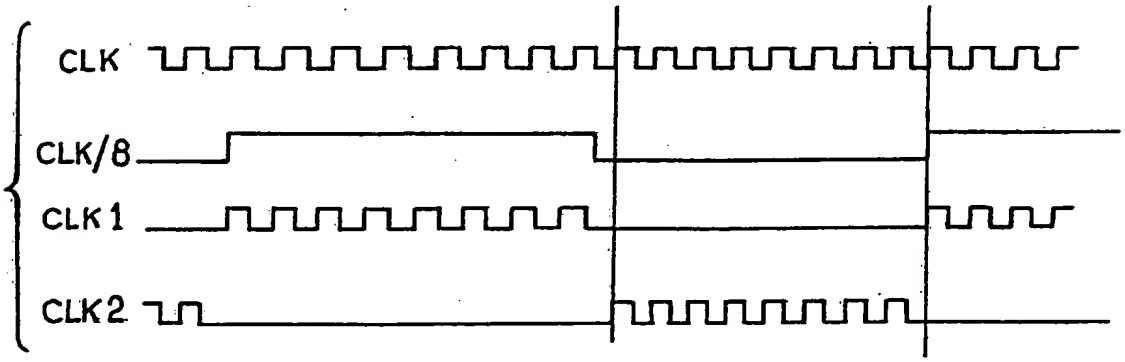


FIG_3

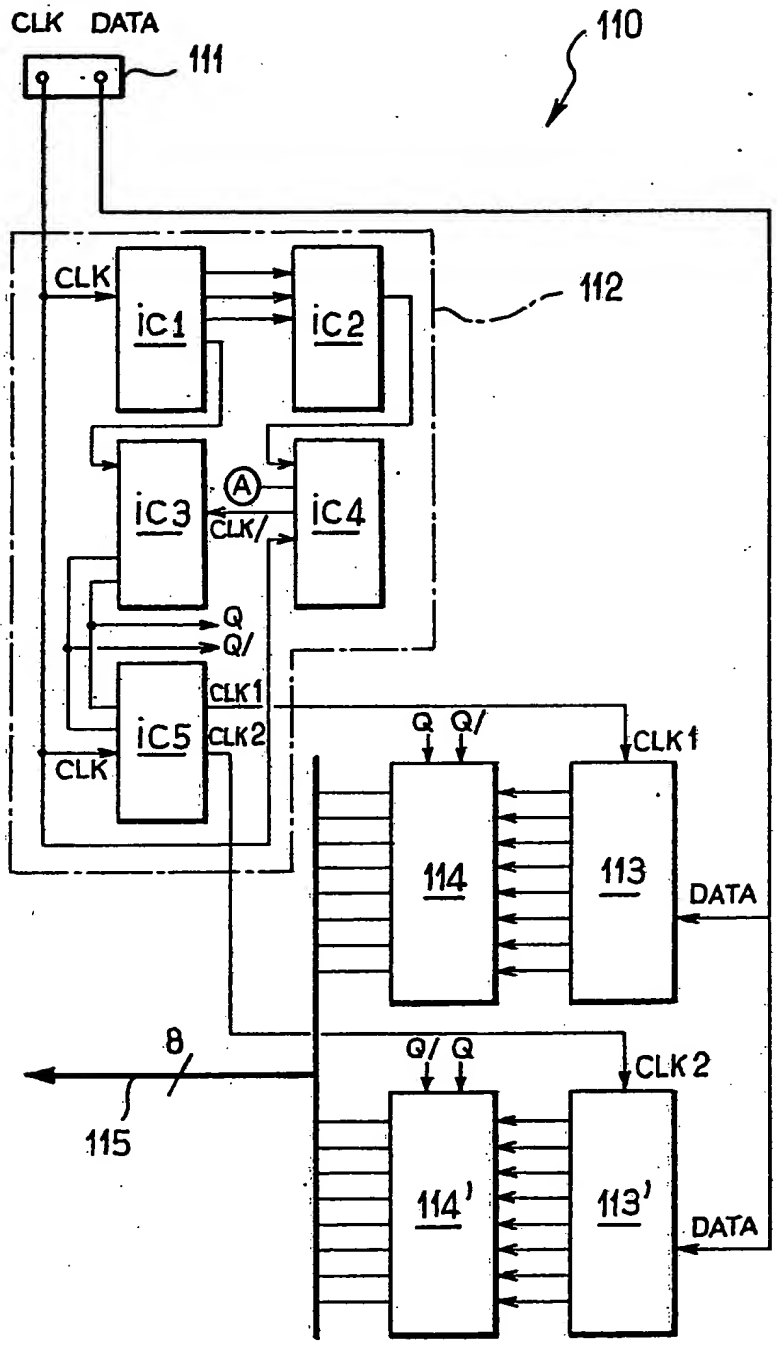

CLK DATA
111
110
CLK
IC1
IC2
112
IC3
A
IC4
CLK/
Q
Q/
CLK1
IC5
CLK2
CLK
Q Q/
CLK1
114
113
DATA
8
Q/ Q
CLK2
115
114'
113'
DATA

FIG_4

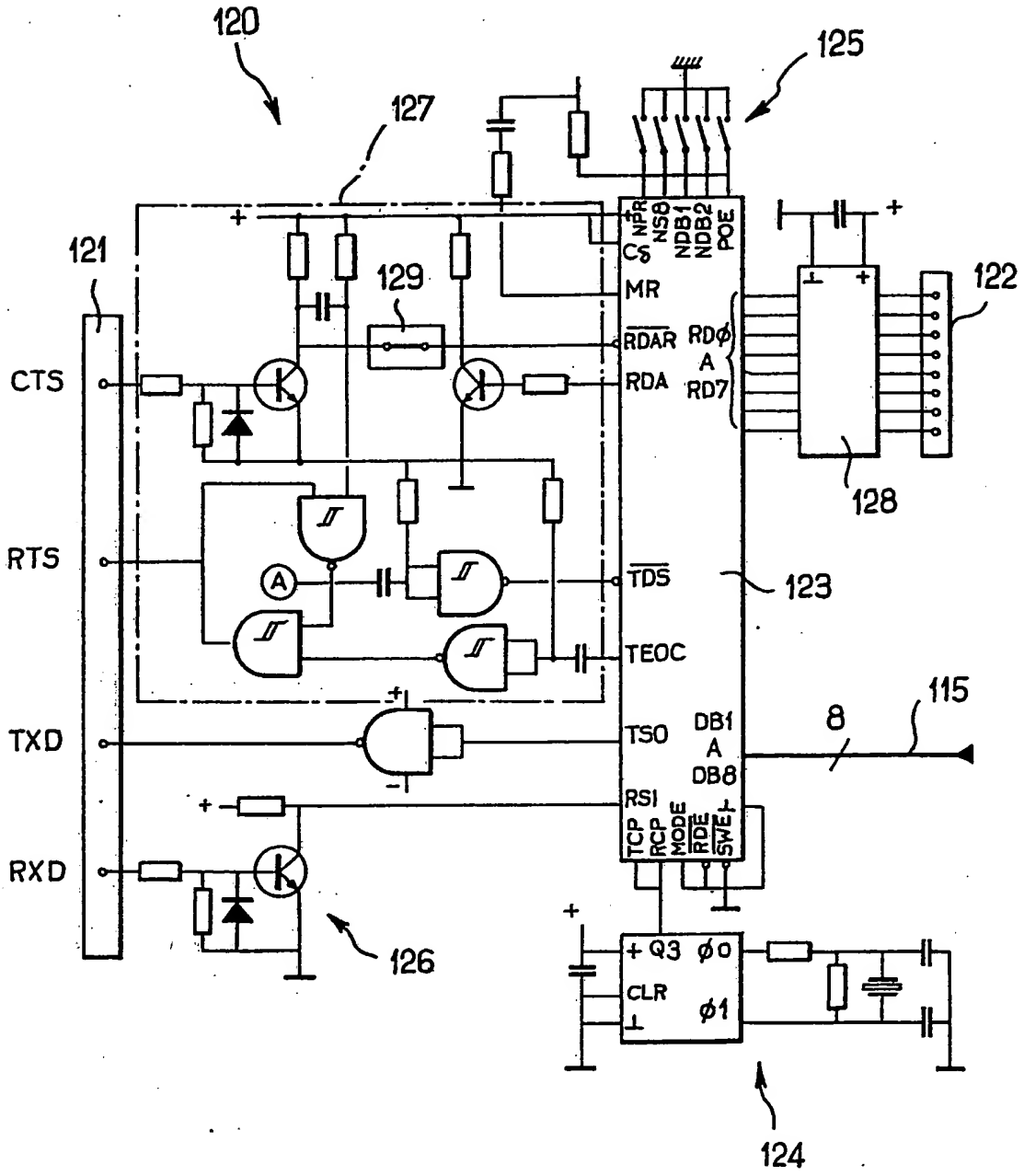

120
125
127
121
129
122
CTS
RTS
TXD
RXD
MR
RDAR
RDA
RDφ
A
RD7
128
TDS
123
TEOC
TSO
DB1
A
DB8
8
115
RSI
TCP
RCP
MODE
RDE
SWE
126
Q3
φ0
CLR
φ1
124

FIG_5

REPUBLIQUE FRANÇAISE

2651352

N° d'enregistrement national

INSTITUT NATIONAL de la PROPRIETE INDUSTRIELLE

RAPPORT DE RECHERCHE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

FR 8911205
FA 430988

DOCUMENTS CONSIDERES COMME PERTINENTS		Revendications concernées de la demande examinée
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	
Y	CH-A- 665 516 (MÜLLER) * Totalité du document *	1-3
Y	EP-A-0 067 384 (DIGITAL EQUIPMENT CORP.) * Page 14, ligne 18 - page 20, ligne 12; figure 1; résumé *	1-3
A	EP-A-0 230 066 (S.A. LA RADIOTECHNIQUE INDUSTRIELLE ET COMMERCIALE et al.) * Page 11, ligne 24 - page 12, ligne 14; figure 5 *	1-3
A	GB-A-2 050 767 (BLAUPUNKT-WERKE-GmbH) * Revendications *	1
A	FR-A-2 554 618 (THOMSON-BRANDT) * Revendications *	1
A	EP-A-0 263 332 (ROBERT BOSCH GmbH) * Totalite du document *	1

DOMAINES TECHNIQUES RECHERCHES (Int. Cl.5)

G 08 G
H 03 M

Date d'achèvement de la recherche: 08-05-1990

Examinateur: REEKMANS M.V.

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
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O : divulgation non-écrite
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T : théorie ou principe à la base de l'invention
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D : cité dans la demande
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& : membre de la même famille, document correspondant

EPO FORM 1503 03.82 (P0413)

Dec. 16, 1958 R. W. PETER 2,864,944

TWO WAY RADIO RELAY SYSTEM INCLUDING TRAVELING WAVE TUBES

Filed May 18, 1954

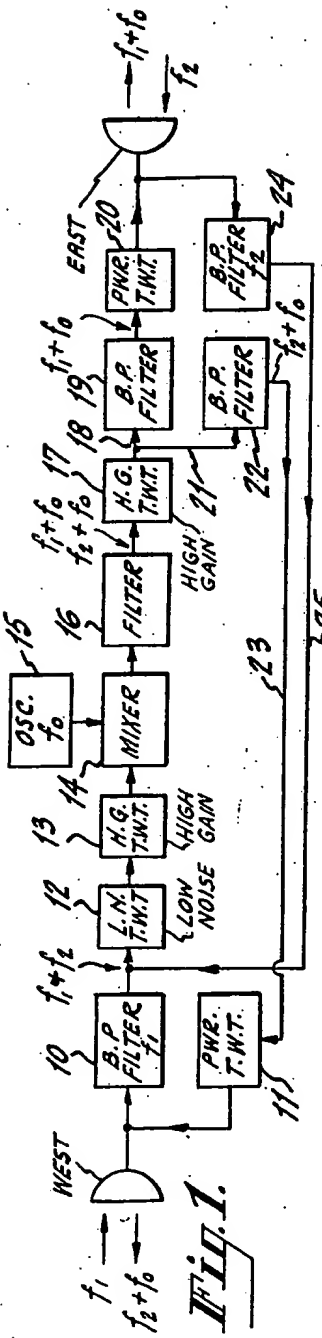

Fig. 1.

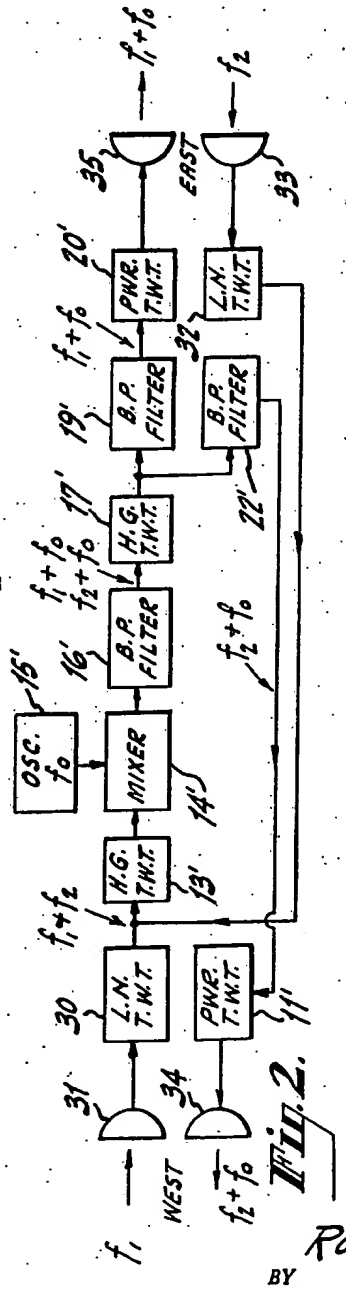

Fig. 2.

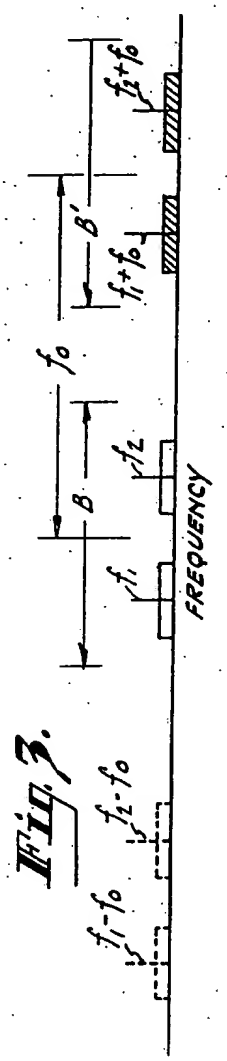

Fig. 3.

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Patented Dec. 16, 1958

2,864,944

TWO WAY RADIO RELAY SYSTEM INCLUDING TRAVELING WAVE TUBES

Rolf W. Peter, Cranbury, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application May 18, 1954, Serial No. 430,660

The terminal fifteen years of the term of the patent to be granted has been disclaimed

2 Claims. (Cl. 250—15)

This invention relates to radio relay systems including traveling wave tubes, and more particularly, to a two-direction radio relay terminal in which the signals going in both directions are passed thru a single path including traveling wave tube amplifiers.

Microwave radio relay stations are known which receive a signal of one frequency range from one direction, amplify the signal, translate the signal to another frequency range, and transmit it in the other direction. The frequency translation is performed, inter alia, to prevent a tendency toward oscillation caused by feed-back from the transmitting antenna to the receiving antenna. If the relay station is required to simultaneously handle messages going in both directions, it has been necessary to provide two complete equipments, one for messages in one direction, and the other for messages in the other direction. It is a general object of this invention to provide an improved radio relay station wherein the signals simultaneously going in both directions are both amplified in a single traveling wave tube amplifying circuit.

The copending but now abandoned application of Frank R. Arams, Serial No. 402,691, filed on January 7, 1954, entitled "Traveling Wave Tube System," and assigned to the assignee of this application, teaches a system for increasing the amplification provided by a traveling wave tube by passing the signal thru the tube, heterodyning the amplified output signal to a slightly different frequency range, and then passing the signal thru the tube again. By this arrangement, a single traveling wave tube can be made to provide substantially double the gain that would otherwise be possible. The present invention differs from that of the above-identified application in that two different message signals are simultaneously amplified in a common traveling wave tube amplifier, the two signals being such as to occupy different frequency ranges so that they do not interfere with one another in the traveling wave tube. It is therefore another object of this invention to provide an improved system for simultaneously amplifying two different signals in a single traveling wave tube amplifier.

The traveling wave tube amplifier of this invention may include a plurality of traveling wave tube circuits coupled in cascade. It is a characteristic of traveling wave tubes that a tube of one design is most useful in amplifying a low level signal in such a way as to discriminate against noise. The same traveling wave tube may be employed with different bias potentials as a high gain or intermediate level amplifier. A traveling wave tube of a second design is most useful as a power amplifier. The low noise traveling wave tube and the high gain traveling wave tube are normally operated as linear amplifiers, and the power traveling wave tube is operated over a range including the non-linear portion of the characteristic curve so as to maximize the power output. So long as a traveling wave tube is operated on the linear portion of its characteristic curve, there is little danger that two signals simultaneously being amplified by the tube will

interfere with each other to cause cross-modulation. The danger of cross-modulation is further reduced if the levels of the two signals simultaneously amplified in the traveling wave tube are of equal value. It is therefore a further object of this invention to provide an improved system for simultaneously amplifying two different signals in a single traveling wave tube in such a way as to minimize the interference between the two signals.

It is a still further object to provide an improved two-direction radio relay station characterized in requiring a minimum number of traveling wave tubes by reason of an arrangement whereby traveling wave tubes are employed to simultaneously amplify the signals going in both directions.

In one aspect, the invention comprises a radio relay station including antennas whereby message signals of different frequency ranges are simultaneously received from the West and from the East. The terms West and East are used for convenience to identify any two directions. Both received signals are applied to the input of a first traveling wave tube amplifier circuit. The output of the amplifier circuit and the output of a local oscillator are both applied to a mixer. The heterodyned output of the mixer is passed thru a filter to eliminate all frequencies except the sum or difference frequencies. The output of the filter is then applied to a second traveling wave tube amplifier circuit. The heterodyned signals in the output of the second traveling wave tube amplifier circuit are separated by filter means. One signal is applied to an antenna directed towards the East and the other signal is applied to an antenna directed towards the West. The West-going and the East-going signals may be separately amplified in separate power traveling wave tube circuits prior to application to the respective antennas. The West-going and the East-going signals are at substantially the same power level in the first traveling wave tube amplifier circuit, and are also at substantially the same level in the second traveling wave tube amplifier circuit. By this arrangement whereby the two signals simultaneously amplified in a traveling wave tube circuit are at substantially the same level, the amplification is performed substantially without interference or cross-modulation between the two signals. One directional antenna pointed in a given direction may be used for receiving and another directional antenna pointed in the same direction may be used for transmitting; or a single antenna pointed in a given direction may be employed for both transmitting and receiving in conjunction with a diplexing network.

These and other objects and aspects of the invention will be apparent to those skilled in the art from the following more detailed description of the invention, taken together with the appended drawings, wherein:

Figure 1 is a block diagram of a two-directional radio relay station constructed according to the teachings of this invention;

Figure 2 is a block diagram of another form of the invention; and

Figure 3 is a chart showing frequency relationships which will be referred to in explaining the operation of the circuits of Figures 1 and 2.

Referring to the radio relay system of Figure 1, a directional antenna West is coupled to the input of a bandpass filter 10 and to the output of a power traveling wave tube amplifier circuit 11. The output of bandpass filter 10 is coupled thru a low-noise (L. N.) traveling wave tube amplifier circuit 12 and a high gain (H. G.) traveling wave tube amplifier circuit 13 to a mixer 14. The mixer 14 may be a crystal mixer or, alternatively, the traveling wave tube amplifier 13 may be employed as a mixer. In either case, a loss of about 6 db is suffered in the mixing operation.

A local oscillator 15 has an output coupled to the mixer 14. Oscillator 15 may be of any suitable circuit configuration, and may include a klystron tube or a voltage-tunable backward-wave oscillator tube. The sum and difference frequencies from mixer 14 are applied thru a bandpass filter 16 to a second high gain traveling wave tube amplifier 17. The output of the traveling wave tube amplifier 17 is applied over line 18 thru a bandpass filter 19 and thru a power traveling wave tube amplifier circuit 20 to a directional antenna East. The output of the traveling wave tube amplifier circuit 17 is also applied over line 21, thru bandpass filter 22, over line 23, and thru a power traveling wave tube amplifier circuit 11 to the directional antenna West. The directional antenna East is coupled thru a bandpass filter 24 and a line 25 to the input of low noise traveling wave tube amplifier circuit 12.

A description of low-noise traveling wave tube amplifiers and traveling wave tube power amplifiers may be obtained from many publications, including an article entitled "New Developments in Traveling-Wave Tubes," by W. J. Dodds, R. W. Peter, and S. F. Kaisel, appearing at pages 130–133 of the February 1953 issue of Electronics magazine.

The operation of the radio relay station of Figure 1 will now be described with reference to the frequency chart of Figure 3. The message signal received from the West consists of a radio frequency carrier frequency f_1 modulated by the intelligence signal. In Figure 3, the carrier frequency f_1 is represented by a vertical line, and sidebands are represented as extending on both sides of the carrier frequency. For convenience, the message modulated radio frequency signal including the sidebands will be referred to as the signal f_1. Similarly, a message modulated radio frequency signal f_2 is received by the antenna East. It will be noted from Figure 3 that the signals f_1 and f_2 occupy different frequency ranges. Radio relay stations normally operate with received and transmitted signals of frequencies displaced from each other. The signal f_1 received from the West is applied thru bandpass filter 10 to the input of the traveling wave tube circuit 12, and the signal f_2 received from the East is applied thru bandpass filter 24 and then also to the input of traveling wave tube circuit 12. Both signals are amplified simultaneously in the low-noise traveling wave tube amplifier 12 and also in the high gain traveling wave tube amplifier 13. The amplifier circuits 12 and 13 are characterized in being able to amplify frequency components over a range B of Figure 3, without distortion and cross-modulation.

The two amplified signals f_1 and f_2 from the traveling wave tube amplifier circuit 13 are now applied to the mixer 14, where they are heterodyned with a signal at frequency f_0 from the local oscillator 15. The output of the mixer 14 is applied to bandpass filter 16, which passes the sum frequencies f_1+f_0 and f_2+f_0, but blocks the original frequencies and the difference frequencies. The sum frequencies from the bandpass filter 16 are then amplified in the high gain traveling wave tube amplifier circuit 17. The amplifier circuit 17 is adapted to amplify all frequencies in the range B′ of Figure 3 without distortion. The high gain traveling wave tube amplifier circuit 17 may be exactly the same as the circuit 13, and the shift in the center frequency of the frequency band amplified may be accomplished by merely adjusting the potential applied to the helical electrode in the traveling wave tube.

The two signals in the output of the circuit 17 are separated by means of bandpass filters 19 and 22. The signal f_1+f_0 from filter 19 is applied thru a power (PWR) traveling wave tube amplifier 20 to the directional antenna East from which it is radiated to the next distant relay station in the direction East. The signal f_2+f_0 from the filter 22 is applied thru the power traveling wave tube amplifier circuit 11 to the directional antenna West from which it is transmitted to the next distant radio relay station in the direction West. Filter 10 prevents the signal f_2+f_0 from returning to traveling wave tube 12. The terms East and West, as stated before, are merely used to distinguish between the two directions which may be any two directions.

It will be noted that the signal received from the East and the signal received from the West are both simultaneously amplified in traveling wave tube amplifier circuits 12, 13 and 17. It will be further noted that the level of these two signals in the three traveling wave tube amplifier circuits is substantially the same in each of the three circuits. Since the two signals in a given circuit are at substantially the same level, there is substantially no cross-modulation between the two signals, if the amplifier is operating in a substantially linear region. Any cross-modulation products are far below the level of both signals. The East-going signal is individually amplified in power amplifier 20, and the West-going signal is individually amplified in power amplifier 11. The amplification of both signals in a single power amplifier is not attempted for the reason that the power amplifiers operate on the non-linear portion of the characteristic curve in order to provide the greatest power gain, and under these conditions two signals going thru the same traveling wave tube would modulate each other and cause cross-talk and interference between the two signals. Additionally, it is preferable for each signal to fully utilize the power handling capacity of a separate tube in the final amplifying stage. The traveling wave tube circuits 12, 13, and 17 in the common path, however, operate on the linear portion of their characteristic curves, and therefore there is no cross-modulation of the two signals.

By way of example to illustrate frequencies which may be employed in the system, a very high quality television signal relay station may employ frequencies wherein f_1=6,000 megacycles, f_2=6,040 megacycles and f_0=120 megacycles. Then f_1+f_0=6,120 megacycles and f_2+f_0=6,160 megacycles. It will be noted from the chart of Figure 3 that the local oscillator frequency f_0 should be somewhat greater than the bandwidth B or B′ of the two signals simultaneously amplified in a single amplifier circuit, to prevent overlapping of the original signals and the heterodyned signals.

Of course, the system may be arranged to utilize the difference frequencies f_1-f_0 and f_2-f_0, in place of the sum frequencies. In any case, the system utilizes one set of the sum and difference frequencies. The set used may be the sum frequencies, the difference frequencies, or one sum frequency and one difference frequency.

Figure 2 shows a modified form of the invention, wherein separate antennas are used for transmitting and receiving. A low-noise traveling wave tube amplifier circuit 30 amplifies solely the signal received by directional receiving antenna 31 West. Similarly, a low-noise traveling wave tube amplifier circuit 32 amplifies solely the signal received by receiving directional antenna 33 East. The outputs of amplifiers 30 and 32 are both coupled to the amplifying and heterodyning chain of circuits, wherein the circuits corresponding to those in Figure 1 are given the same reference numerals, with prime designations added. The output of power traveling wave tube amplifier circuit 11′ is coupled solely to the transmitting directional antenna 34 West, and the power traveling wave tube amplifier 20′ is coupled solely to the directional transmitting antenna 35 East.

It is apparent that in the systems of Figures 1 and 2, the arrangement whereby the traveling wave tube amplifier circuits are used to amplify both the East-going signal and the West-going signal results in a very considerable economic saving. Traveling wave tubes are relatively complicated and expensive to manufacture. Therefore, any arrangement whereby the required number of traveling wave tubes is reduced, is of great commercial

importance. According to this invention, the required number of traveling wave tubes is greatly reduced, and yet the performance of the system is maintained at a very high level. The advantages of the system accrue from the facts that the two signals which simultaneously pass thru a given common traveling wave tube amplifying circuit are at substantially the same level or amplitude, to thereby substantially reduce cross-modulation, and that the bandwidth characteristics of the traveling wave tubes are utilized to simultaneously amplify two message signals displaced in frequency.

What is claimed is:

1. In a radio relay station for simultaneously amplifying and relaying separate radio frequency signals of different frequencies and carrying different intelligences, means for feeding said signals of different intelligences through a common path including in cascade in the order named, at least one traveling wave tube amplifier circuit, a mixer, and a filter passing the sum frequencies from said mixer; a local oscillator, means for applying the output of said oscillator as heterodyning energy to said mixer, said oscillator having a frequency greater than the width of the frequency band occupied by said signals taken together, whereby said separate signals are heterodyned to signals of frequencies different from each other and not overlapping the frequencies of the original signals, a pair of filters each having an input coupled to the output of said first-named filter and operating to separate said different frequency heterodyned signals, and separate means coupled to the output of each of said last-named filters for relaying said different frequency heterodyned signals to other relay stations.

2. In a radio relay station for simultaneously amplifying and relaying separate radio frequency signals of different frequencies and carrying different intelligences, means for feeding said signals of different intelligences through a common path including in cascade in the order named, a first traveling wave tube amplifier circuit, a mixer, a filter passing the sum frequencies from said mixer, and a second traveling wave tube amplifier circuit; a local oscillator, means for applying the output of said oscillator as heterodyning energy to said mixer, said oscillator having a frequency greater than the width of the frequency band occupied by said signals taken together, whereby said separate signals are heterodyned to signals of frequencies different from each other and not overlapping the frequencies of the original signals, a pair of filters each having an input coupled to the output of said second traveling wave tube amplifier circuit and operating to separate said different frequency heterodyned signals, and separate means coupled to the output of each of said last-named filters for relaying said different frequency heterodyned signals to other relay stations.

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